PITT RIVERS MUSEUM
UNIVERSITY OF OXFORD

Stone-Worker's Progress

A Study of Stone Implements in the Pitt Rivers Museum

BY

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PREFACE

The author has worked for many years in this Museum and in the National Museum of Canada, has long been associated with the gun-flint makers of Brandon in Suffolk, and has for many years been making stone implements with the simple tools used by ancient and modern Stone Age peoples. At the Curator's request he undertook the teaching of Stone Age techniques in the Museum, and in the course of teaching prepared a series of exhibition cases with explanatory screens representing the principal ancient and modern Stone Age implements and the methods of making them. At the same time he prepared a manuscript book, which has been used for some years in teaching our pupils who study Ethnology and Prehistory. It is this book which we offer as Number 6 of our *Occasional Papers on Technology*, as we have found over a long time that his method of exactly describing experimental procedure and following this with literary evidence from various observers is useful to students. Examination of specimens is confined to our own large collections, so that students can check every detail described. In the first paper of this series, 'The Manufacture of a Flint Arrow-head by Quartzite Hammer-stone', the writer made the first fully clear and literate presentation of the 'turned edge', or prepared marginal striking-platform necessary for getting good flakes across from both sides to meet and make a thin section. Professor A. P. Elkin of Sydney had noted that H. Basedow in *The Australian Aboriginal* of 1929 had mentioned rubbing and rasping the edge to clear away small chips, and on receiving a copy of Sir Francis Knowles's paper, sent observers among the aboriginal stone workers to watch their procedure. They found that the makers of stone and glass lance-heads turned the edges to prepare striking-platforms exactly as Sir Francis Knowles had done in making flint implements (Elkin, 1948).

In the present book the author does not restrict himself to one object as in the former paper, but treats the progress of the stone implement maker from ancient to modern times in both the Old World and the New, dealing with the principal types of flaked implements. While his own experimental work is confined to the use of the quartzite hammer-stone and the bone or antler pressure flaker, he takes account of the experimental work of those who use hammers softer than the stone they strike,

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made of wood, horn, antler, or bone, and in Chapters V to VII, and particularly in Chapter VII, compares the methods and the results of the two techniques according to the evidence of experimenters and of the flaked implements of ancient and modern peoples.

The illustrations are mainly photographed from the writer's own drawings for the screens in the Museum. The originals are modelled in colours and ink, but as the cost of showing them thus was prohibitive they have been photographed by Mr. K. H. H. Walters in the Museum. Other drawings have been made in the Museum by Mr. I. M. Allen. To avoid overloading the text with bibliographical details these have been collected in a list at the end, and references in the text are usually confined to naming the author, year, and page in a parenthesis.

Acknowledgements appear in the author's Foreword.

T. K. P.
B. M. B.

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CONTENTS

FIGURES IN THE TEXT

SIR FRANCIS KNOWLES

Sir Francis Howe Seymour Knowles, fifth baronet, died on 4 April 1953 in his home at Oxford at the age of 67. Though he came of a distinguished naval and scientific family, he read law at Oriel College, Oxford, but returned to science for his post-graduate work. In 1908 he was one of the first two students to be awarded the Diploma in Anthropology, and took his B.Sc. degree in 1911.

From 1909 to 1912 he taught physical anthropology at Oxford, helping Professor Arthur Thomson to establish the subject on a firm basis. During this time he catalogued and measured the large collection of skeletal material in the University, a collection comparable in size and importance to that measured by Sir William Turner in Edinburgh and that by Sir William Flower in London. In 1911, with Sir Arthur Keith, he published in the *Journal of Anatomy and Physiology* 'A Description of Teeth of Palaeolithic Man from Jersey', and in 1912–13 his work on the so-called Red Lady of Paviland, undertaken at the request of Professor Sollas, proved the skeleton to be that of an Aurignacian man. In 1914, after a period of studying the Iroquois, he was appointed physical anthropologist to the Canadian Government, and his monograph on *The Physical Anthropology of the Roebuck Iroquois* was published by the National Museum of Canada.

During his field-work among the Iroquois he contracted typhoid fever, and through lack of proper medical attention, never fully recovered his health. From 1919 he turned his attention to the techniques used by ancient and modern peoples in the manufacture of their stone implements, working only with the materials and tools known to be used by them, until he was able to equal their work. His principal discovery was that of 'turning the edge', or preparing a striking-platform along the edge of an implement so that he could flake across it and get a thin and even section. This discovery was first published in 'The Manufacture of a Flint Arrow-head by Quartzite Hammer-stone' in this series, and within a year of the arrival of the paper in Australia, Professor Elkin published the fact that the author's experimental work had been fully corroborated by actual observation among the tribes of northern Australia. For many years Knowles had been teaching and arranging exhibitions in the Pitt Rivers Museum to illustrate Stone Age techniques, and shortly before his

death had gathered this material together into the present volume, though he did not live to see any of the proofs of the book

Much of the skill and knowledge which he acquired by years of observation and experiment has been passed on to members of the Museum Staff, notably to Mr. W. C. Brice and to Mr. I. M. Allen, for he was most generous in the gift of his time and knowledge, and of a character to develop in his pupils affection, respect, and a desire for hard work. Both he and Lady Knowles always followed the work of the Museum, of whatever sort, with the greatest and most helpful interest, and knew all of the Staff to the youngest apprentice, and noted their progress with approval.

His interests ranged widely over the activities of Stone Age people, ancient and modern, and the Museum contains many examples of his work besides that on stone implements. An especially interesting exhibit is of wire models of flights of boomerangs which he threw, and Mr. H. F. Walters modelled under his direction, showing the shape of the flight, and the position of the boomerangs at each stage of the flight from the start to the return.

All of his work, both in the Museum, and in his publications, was based on exact observation and experiment. His work will endure, and his example will live in those he taught, and will be passed on.

T. K. P.

PUBLICATIONS OF SIR FRANCIS H. S. KNOWLES, BT.

1911. 'Report on Human Remains found in the neighbourhood of Newport, Mon. I. From the Ifton Limestone Quarries.' (II. 'Report on Human and other remains from the Alexandra Dock, Newport', published with the foregoing, was written by Professor Arthur Keith.)
Published by order of the Newport Free Library and Museum Committee, Newport, Mon.

1911. 'The Correlation between the Interorbital Width and the other Measures and Indices of the Human Skull', *JRAI*, xli, July–Dec., pp. 318–49.

1911. (With Professor Arthur Keith.) 'A Description of Teeth of Palaeolithic Man from Jersey', *Journ. of Anat. and Physiol.* xlvi. 12–27.

1913. (In W. J. Sollas, 'Paviland Cave: an Aurignacian Station in Wales', *JRAI*, xliii, Huxley Lecture). Description of the Bones.

1915. 'The Glenoid Fossa in the Skull of the Eskimo', Canada, Department of

Mines, Geological Survey; *Museum Bulletin* no. 9, Anthropological Series, no. 4.

1937. (With A. S. Barnes). 'Manufacture of Gun-flints', *Antiquity*, xi. 201–7.

1937. 'Physical Anthropology of the Roebuck Iroquois', National Museum of Canada, Department of Mines and Resources, *Bulletin* No. 87, Anthropological Series, No. 22.

1941. (With T. K. Penniman). 'An Obsidian Blade found near the University Parks at Oxford', *Man*, vol. xli, no. 88.

1944. 'The Manufacture of a Flint Arrow-head by Quartzite Hammerstone'. Pitt Rivers Museum, *Occasional Papers on Technology*, no. 1.

1953. 'Stone-Worker's Progress, a Study of Stone Implements in the Pitt Rivers Museum'. Pitt Rivers Museum, ibid., no. 6.

FOREWORD

The scope of primitive stone-working is an enormous one. It goes back in time for hundreds of thousands of years. It ranges in area from America round the world to Australia. It varies from the flaking of siliceous material for tools and weapons, to the shaping and carving of rock masses in architecture.

But in the striking of flakes from flint and other siliceous stone, it is likely that the first attempts made by man were to make sharp and durable implements. It is because of the very durability of these tools that they will often be the only evidence still left of man's progress in intelligence and skill, from the early days of tool-making to the time, before metal had superseded stone, when the latest examples of his work show the advances he had made in technical achievement.

We, viewing a representative collection in a museum, can look back and see telescoped, as it were, a vast period of time and development. To us the forward steps seem obvious. But the early stone-worker had not our advantage of seeing what lay ahead; he could only build little by little on the store of technical tradition passed on from one generation to another.

Looking back in this way over the past, the impression one gets of stone-working Man is that of a patient, intelligent craftsman; crude in the early days, but nevertheless even then possessing great hand-skill and an artistic appreciation of symmetry of form; a craftsman who by experiment, invention, and intelligence gradually acquired the mastery over his material, until in the final phases of the Stone Age he could not only produce highly efficient and artistically satisfying tools and weapons of flint, but could also manufacture implements from hard stones and rocks that, being unflakeable, were of no help to him in earlier times. For during this last phase, Man had learned to work his material by pecking and grinding, so that he could shape hard rock into axes; by sawing, so that he could cut out slabs of nephrite and jade-like stone to shape; and by boring, so that he could make shaft-holes in hard pebbles for clubs and stick-weights, and in shaped axe-heads of stone.

But still in many areas in which suitable flinty material occurred, Man continued to use it. Taking a general view of the Stone Age, the complexity of flint tools and their specialization in type went hand-in-hand

with changes and improvements in flaking methods, and show the increasing complexity of Man's life, his restless inventive genius, and his technical progress.

Since, therefore, the flaking techniques are at once the earliest and the latest stone-working methods, and since they cover much of the range of man's technical progress, it seems of interest to attempt some survey of the technical advance of flint work by investigating the development of some well-known types of flint implements whose manufacture illustrates flaking techniques.

The present research, therefore, is confined to the flaking of siliceous stone in the manufacture of the axe, spear-point, knife, and arrow-head, and the core from which flakes were struck to make tools. For with the inclusion of the core, the evolutionary technical history of these five products of the stone-worker will serve to illustrate Man's progress in the flaking of flint and other siliceous stone.

Some account has been included of recent Stone Age native peoples, for the light these throw on the methods used by prehistoric peoples in the manufacture of similar flint weapons and tools, and some attempt has also been made in this paper to illustrate the adaptability, skill, and liberty of choice that characterizes the manufacture and use of stone implements by primitive Man.

Acknowledgements

For access to the magnificent stone-implement collections in the Pitt Rivers Museum, and for permission to use the specimens as a foundation for this research, I am indebted to the courtesy of the Curator, Mr. T. K. Penniman. I am deeply indebted to the Curator and to Miss Beatrice Blackwood, University Demonstrator and Lecturer in Ethnology, for the publication of this paper in the *Occasional Papers on Technology* issued by the Museum, and for their kind assistance in its preparation for publication. To Mr. John Bradford, University Demonstrator and Lecturer, I am very grateful for assistance on so many occasions during work on the collections. I am grateful also to Mr. I. M. Allen, who drew several of the specimens for me, and to Mr. K. H. H. Walters for photographing my own coloured drawings from the screens which I prepared to accompany the exhibition of Techniques in Stone-working in the Pitt Rivers Museum.

To the late Professor Henry Balfour, formerly Curator of the Pitt Rivers Museum, I am indebted for his advice in my youthful collecting

days to collect not merely the 'battle-axes' but also every flake and flaked piece found by the workmen in the Biddenham gravels. The useful results of this advice may be seen in Chapter VII of this paper.

In Chapter VII may also be seen my debt to my old friend and collaborator Professor Alfred S. Barnes, for this chapter is largely based upon the unique teaching collection that he made for the Pitt Rivers Museum. In spite of age, failing health, and failing eyesight, he continued in his last year to give me his advice and assistance in the preparation of the earlier pages of Chapter VII, so as to ensure that the definitions and the notes on his specimens should be correctly worded. His work in the Pitt Rivers Museum will remain as a monument to his originality, his exactitude, and his enthusiasm.

F. H. S. K.

2 September 1952

INTRODUCTION

THE following notes on the development of some flint-flaking techniques are based upon:

1. Experimental work.
2. A study of the stone-implement collections in the Pitt Rivers Museum.
3. The technical methods of the recent native stone-worker as recorded in literature by European observers.

Before commencing the technical part of this paper, it may be helpful to define the use of the term 'technical progress', and to set forth, necessarily in a very compressed and generalized way, certain changes or phases in the Stone Age which are marked by stages in technical advance in stone-working.

Technical Progress

Stone-working is the adventure of Man with a material, stone, from which he wanted to make some of his tools and weapons. 'Progress' then to the stone-worker will mean better ways of dealing with stone, and better and more efficient implements made from it. It is in this sense that the words 'advance' and 'progress' are used by the writer, and his point of view is that of the experimental worker.

Stone Age Phases

A survey of the stone implements in the Pitt Rivers Museum impresses the observer with an evident series of stages or phases through which Stone Age Man passed in the course of his technical development. These phases would appear to represent a series of steps in his intellectual and technical progress, characterized, so far as stone-working is concerned, by the manufacture and use of certain types of stone tools and accompanied by an increasing variety and specialization in the form of the stone tools and implements. Many of the tool-types were made and used by peoples living in far separated areas of the world.

Although for purposes of clarity the phases have been divided into 1, 2, &c., it must be emphasized that in reality there was no abrupt transition from one class to another, but just a gradual evolution in which the superior gradually supersedes the inferior and in which the older and

newer techniques may occur side by side for a while. Professor D. A. E. Garrod's collections (Garrod and Bate, 1937) from Et Tabun Cave, Mount Carmel, in Palestine, show very strikingly the gradual supplanting of tool-types and techniques by improved patterns and methods; and in the specimens presented by her to the Pitt Rivers Museum, the following examples may be seen to illustrate the slow changes in any phase.

In *Layer F, Upper Acheulean*, hand-axes, 'tortoise'-cores, Clacton-type cores, and flake tools all occur together.

In *Layer Ea and Eb, Upper Acheulean* (*Micoquian*), there are relatively few hand-axes, but an increase in the size and number of flake and blade tools; Audi, Chatelperron points, and burins appear. 'Tortoise'-cores, *and* a Clacton-type core are among the specimens from this layer in the Pitt Rivers collection. These examples will serve to illustrate the slow transition that took place during the phases.

Seeing the variety of tool-types used, and the skill shown in their manufacture, by the men of the Lower Palaeolithic period, it is only reasonable to presume that a long history of flint-work went on before it, and that there were preceding stages of flake and/or flaked-pebble industries and the use of simpler and less specialized tools.[1]

1. But the *earliest phase* selected from the Pitt Rivers collections is that characterized by the pear-shaped hand-axe, the distinctive tool of the European Lower Palaeolithic, *c.* 550,000–250,000 years ago (see Table, p. 21). There were flake-implements and plain flakes also in use, of course, but the hand-axe was made in large quantities and appears to have been a general-purpose cutting, chopping, and piercing tool; in technical descent it developed from the flat pebble or nodule sharpened by edge-flaking. Made of the same shape and in the same flaking-pattern, the hand-axe is represented in the Museum by specimens from England, France, Palestine, Africa, and India. Specialized forms were developed; in South Africa, for instance, a cleaver form with flat cutting-edge was much used. The prevailing core technique of the early part of this phase was the Clacton-type alternate-platform method of flake production.

2. *The next phase* is that characterized by the dominance of the 'tortoise'-type core technique. The worker had now found that by preparing a core in a certain way, he could strike off large flake implements with sharper, straighter edges than those of the biface hand-axe, and that

[1] It is hoped one day to publish some of these early specimens in connexion with the exhibition made for the Pitt Rivers Museum by Professor Barnes, showing natural and human flaking of stone.—*Editors.*

furthermore by this method he could obtain flake-implements of sizes and shapes that he could vary at will. That the hand-axe accompanied this phase for part of its way may be seen in Professor Garrod's Mount Carmel collections. This technique dominated the European Middle Palaeolithic period, *c.* 250,000–100,000 years ago (see p. 21), and is represented in the Pitt Rivers Museum by specimens from England, France, Palestine, and Africa.

3. *The third phase* is characterized in the Upper Palaeolithic of Europe, *c.* 100,000–12,000 years ago (see p. 21) by specialization in flake-tools (or blade-tools), e.g. the use of many varieties of burin and scraper, and with this a change-over to a new technique of flake-production, namely the use of Brandon-type and two-or-more-platform cores (side-flake or end-platform cores), instead of the Middle Palaeolithic 'tortoise'-type cores (top-flake or multiple-platform cores). Accompanying these changes there came also the development of diffuse-bulb (see Chapters VI and VII) techniques in flake and implement manufacture. Tools of this 'Upper Palaeolithic' type were used in Europe, Asia, and Africa in prehistoric times, and in recent times similar tools were in use among many Stone Age peoples.

4. *The fourth phase* is characterized in the Mesolithic of Europe, *c.* 12,000–3,000 years ago (see p. 21), by the development of small implements[1] of geometric shape made from flakes or parts of flakes. It is possible that this phase may be based upon the development of handles for flint tools made from wood, bone, or antler, for with a handle of such materials there would be no need of a large stone tool for certain forms of work, while wooden or bone spear-heads and knives could be armed and rendered very effective by the insertion of rows of sharp flint pieces shaped for the purpose. In order to obtain small flakes to make these geometric-shaped pieces, a specialized core industry was developed, and these small, finely flaked cores and their accompanying flakes are found in many and widely separated areas. But the mystery remains as to why in all these areas the little geometric tool-forms should so exactly resemble each other. The Pitt Rivers Museum possesses specimens from England, Palestine, Ceylon, and Africa. In near-modern times they appear to have been made and used by the Bushmen of South Africa, and they are even found in south-east Australia, though their use there seems to have been discontinued before the arrival of the European.

[1] Large implements are also found, and in forested areas there may be seen the beginning of the fifth phase of grinding and polishing large implements.

5. *The fifth, and last, phase* was characterized by the invention of grinding methods in stone-work, and accompanying or following on from this the techniques of hammering, pecking, and battering of unflakeable stone into shape. By these techniques hard and unflakeable stones and rocks could be turned into very efficient adzes with sharp and polished edges, and flaked-stone adzes could be ground and polished into form, and provided with sharp and symmetrical working edges. In some areas where siliceous material was plentiful and of good quality, this stage was also marked by the manufacture of very finely flaked knives, spear-heads, and arrow-heads. In European prehistory the fifth and last phase characterizes the Neolithic period, *c.* 3,000–2,000 B.C. (see p. 21), though grinding and polishing, especially in the forested areas, had begun in the Mesolithic period. The 'Neolithic' stone-working techniques were also widespread among the Stone Age peoples of modern and near-modern times.

In the course of the last Stone Age phase in Europe came the discovery and use of metals, and the gradual abandonment of stone as a material for the manufacture of tools and weapons.

It is perhaps needless to say that other materials besides stone, e.g. bone, antler, shell, and wood, were also used by Stone Age man. But stone implements, being the more lasting, form now the most reliable record available of early Man's progress in tool and implement manufacture.

Time-Periods

The following table for the time-periods mentioned in connexion with the technological phases was prepared by Mr. T. K. Penniman, Curator of the Pitt Rivers Museum, and has appeared in his *A Hundred Years of Anthropology*, and in *Man and other Living Things* by Dr. F. G. W. Knowles. The Palaeolithic 'dates' follow Professor C. F. C. Hawkes in 'Prehistoric Time', *The Museums Journal*, September 1941.

This table illustrates the long slowness of the technical advance in the Early Stone Age, the gradual quickening in the later stages of the Stone Age, until with the discovery of metals a revolution took place in technique, and change succeeded change in hurrying sequence.

Chronology and Terminology

It should be noted that although the technological phases marked time-periods such as Palaeolithic, Mesolithic, and Neolithic in Europe,

for example, yet in modern times Stone Age peoples in various parts of the world were still using tools and techniques characteristic of those used by our own ancestors of the European Neolithic and Mesolithic, and even as far back as the Upper Palaeolithic period. For example, the nosed scraper so much used by Aurignacian man in France at the beginning of the Upper Palaeolithic period there, was equally useful to the Tasmanian natives of recent times, and was made in large quantities by them. The European terms are therefore of use in the comparison between native stone-working techniques and tool-types, but have no relation from the point of view of chronology.

Cultural Periods of Early Man

Period	*Time*
PALAEOLITHIC	
Lower Palaeolithic. Abbevillean (Chellean), Acheulean, Clactonian, Early Levallois.	c. 550,000–250,000 years ago.
Middle Palaeolithic. Late Acheulean and Clactonian, Levallois, Moustierian.	c. 250,000–100,000 years ago.
Upper Palaeolithic. Aurignacian, Solutrean, Magdalenian.	c. 100,000–12,000 years ago.
MESOLITHIC	c. 12,000–5,000 years ago.

Later Periods

Western Europe	*Western Asia and Egypt*	*China*	*Period between*
Mesolithic	Neolithic	Mesolithic	5,000–4,000 B.C.
Mesolithic	Chalcolithic[1]	Mesolithic	4,000–3,000 B.C.
Neolithic	Chalcolithic Bronze	Neolithic	3,000–2,000 B.C.
Bronze	Bronze, then Iron	Bronze	2,000–1,000 B.C.
Iron	Iron	Iron	1,000–500 B.C.

[1] A period when copper and stone were both used for tools.

Thus, taking the stone implements alone as a guide, the Tasmanian natives were in the 'Upper Palaeolithic' stage, i.e. they did not use geometric tool-forms, nor did they use grinding techniques, while many of their tools were similar in type to those used in the European Upper Palaeolithic. The Australian aborigines were in the 'Neolithic' stage, i.e. their stone-working techniques and implement-forms were akin to those

used in the European Neolithic period. The Bushman seems to have been 'driven back' into the 'Mesolithic' stage by the incursions of hostile iron-armed negro tribes (see p. 102). In America there were existing in the same time-period the Eskimo, working in stone, bone, and ivory, and also treating meteoric iron and raw copper as stone by knocking flakes from iron meteorites and cold-hammering raw copper into shape, Indian tribes similarly treating copper, other Indian tribes 'Neolithic' in their use of stone, bone, and antler, and the Incas of Peru, who had reached a high level of civilization, and were technically in the 'Bronze Age'.

By-passing of Phases

Africa affords a striking example of the possibility of the by-passing of a technical stage, for the use of iron in ancient Egypt spread ultimately to the Negro tribes while they were still in a stone age, so that they never went through the phase of making and using bronze. A modern example of quick technical change is the advent of the European into the stone-working areas of the world, and the tremendous upheaval thus caused in the lives of the stone-working native peoples.

Disappearance of some Tool-forms, and Survival of Others

It seems that a tool may be of great use at one time or place, and yet be superseded and disappear entirely in later times or other areas. For instance, the burin so widespread in the Upper Palaeolithic of Europe, Palestine, and Africa, is not found in the modern Stone Age native industries. How is it that a tool so essential at one epoch should have vanished at another? The only reasonable answer seems to be that it was superseded by a more efficient tool-form.

On the other hand, the round-ended stone scraper, used for dressing skins, maintains its uninterrupted course from the prehistoric Lower Palaeolithic period to the hands of the modern Stone Age native, for it has proved to be all-sufficient for its purpose through all the changing conditions of primitive life from early to late Stone Age times, and even into the Early Metal Age, and to modern times.

Similarity in Stone Implement Types

An interesting fact, also, is the widespread use of certain tool-forms in far separated areas. For the burin and certain scraper-forms are represented in the Pitt Rivers collections from the Upper Palaeolithic of France and Belgium, and among the obsidian tools collected in Kenya

and presented by Dr. L. S. B. Leakey. The use of the Aurignacian-type nosed scraper by the Tasmanian natives has already been mentioned (see p. 21).

Diversity in Stone Implement Types

On the other hand, it should be noted that although implements of the same form are used by so different and so widely separated peoples, yet there are also examples of the inventions of weapons or tool-forms peculiar to certain areas or peoples. The small stone adze (*tula*) made from the bulbar end of a flake by the Australian aborigine seems likely to be an instance of the invention of a tool-form not found elsewhere.

As some striking examples of stone implements that are characteristic of certain peoples may be mentioned the handled Danish flint knives and daggers, the fluted-flaked Predynastic Egyptian chert knives, the long flaked-chert 'swords' of the American Indian found in Tennessee, and the well-known *meres* of the Maori chiefs. There are, indeed, some stone implements so distinctively developed in certain areas, that in any collection their place of origin can be seen at a glance; while there are others, such as the flake-knife, the flaked arrow-head, spear-head, and knife, the almond-shaped, flaked or polished, wood-working stone adze, and the ubiquitous skin-scraper, whose manufacture and use are the same the world over, and whose provenance may often only be judged by the variety of siliceous stone used, or by minor differences in form.

Summary

Stone-working has passed through a series of technical stages or phases in the course of Man's intellectual and technical development. These stages are characterized by the use of certain stone tool-forms and stone techniques. In Europe they correspond to certain time-periods in accordance with the chronology determined by geological research in this part of the world. They are here prehistoric in date. But in some out-lying areas of the world there has been a considerable time-lag, and numerous native peoples have been until recently at the same technical stage as our own far-off ancestors. It was the voyages and explorations of the Iron Age European that changed abruptly this state of things and brought the Stone Age to an end. There is a very striking similarity in stone tool-forms in widely separated areas; there is also considerable diversity of type.

Chapter I

SELECTION TO ILLUSTRATE FLAKING TECHNIQUES: THE 'AXE', SPEAR-HEAD, KNIFE, ARROW-HEAD, AND CORE

THE implements whose technical history has been selected to illustrate the progress of the stone-worker are the axe, spear-head, knife, and arrow-head, made by flaking techniques from flint and other siliceous stone, and with them has been included the core of siliceous stone, i.e. the block from which the worker struck off the flakes he required, either to be used plain or to be manufactured into knife, spear-head, or arrow-head. For the technical methods of core-flaking were applied by the primitive stone-worker to the manufacture of his flaked implements, and vice versa.

The flaked spear-head, knife, and arrow-head of the Stone Age correspond sufficiently well to their Metal Age equivalents to make their names satisfactory. But the Stone Age axe is an implement quite different from the modern iron or steel axe.

The Palaeolithic Hand-axe

The earliest stone 'axe', the Palaeolithic hand-axe (Fig. 1), is in essentials a heavy, cutting, and sharp-pointed tool that was held and used in the hand. In the later Lower Palaeolithic period it developed into various specialized types, such as the chopper, cleaver, and long dagger-like implement. In its characteristic pear-shaped Palaeolithic form it gradually died out, being probably replaced in the Middle Palaeolithic by more specialized tools. But as crude chopper or pick, its equivalent is likely to have been used through all the Stone Age periods, and it may be represented among modern Stone Age peoples by the Bushman[1] chopper, the Australian[2] well-flaked pebble chopper, the Tasmanian[3] pebble pick or chopper crudely sharpened by flaking, and in America by implements such as the Oregon[4] chopper-like tool in the Pitt Rivers collection, and the chopper-like implements found in Patagonia.[5]

[1] This, and subsequent numbers, refer to notes at end of chapter.

Fig. 1. Palaeolithic hand-axe, Broom gravels, Axminster (author's collection).

The Neolithic-type Stone Adze

The Late Stone Age adze (Fig. 2) is a wood-working tool. It was in use among the peoples of the Neolithic period, among the modern Stone Age peoples in many parts of the world, and over a long range of time. It was made, in its characteristic form, with its business-end shaped like a shallow and flattened scoop or gouge,[6] and was hafted and used in adze-fashion,[7] working the wood by gouging out chips and slices. It had axe-like variants in flaked and polished form.[8] There were also axe-like hoe-blades that were made and used formerly in some eastern areas of North America by Indian tribes.[9] The Neolithic-type adze may be flaked and thus used, or first flaked and then ground, either wholly or partly, into a final polished form, or hammered and pecked from hard stone and ground into shape.

The Modern Metal Axe

The modern iron or steel axe is in essentials a hafted wedge; one blow cuts into the wood at a slant, the next drives in and meets the bottom of the previous cut at an angle, thus removing a chip or slice between the cuts.

Since in this study the technique of the blocking out and shaping of a flaked-flint axe or adze is the main point, the implement will be referred to as an 'axe', since the course of manufacture is the same until the final shaping of the working-end for the purpose for which it is intended.

Notes

1. See Dunn, 1931, Plate V, fig. 3 for a chopper in the collection presented by Mr. E. J. Dunn to the Museum (cat. 1940.10.9, D.V. 3). This specimen is flaked in the palaeolithic manner across one face only, and is pear-shaped, but the sharp 'butt' appears to have been the business-end.

2. For a study of Australian flaked pebbles see Cooper, 1943. Some are flaked across one face from one margin only, i.e. are semi-uniface implements; others from both margins, so that one face is wholly cross-flaked, i.e. are uniface-implements.

3. The Tasmanian flaked pebble implements are represented in the Pitt Rivers Museum among the very large collection made by Mr. E. Westlake. These particular implements in the collection vary in size, one being very large and heavy. They are flattened, oval, and pear-shaped, and their ends (one end only of each) have been sharpened and pointed by flaking across one face only.

4. A large flaked oval 'hand-axe' in the Museum comes from Lake County,

Fig. 2. Neolithic stone adze, Eastbourne (author's collection).

Oregon, and was presented by Mr. T. B. Kittredge in 1913 (cat. V. 76). It is boldly flaked, of thin section, oval shape, and of fine workmanship. It appears to have been a chopping implement, is a finely made biface, and very superior in technique to the crude Bushman and Tasmanian implements just noted.

5. For the use of crude choppers of hand-axe shape in Patagonian antiquity see Bird, 1938. These implements are figured on p. 272, and on p. 253 are said to be unilaterally flaked. They appear to be similar to the Bushman chopper described in note 1.

6. In its characteristic wood-working form, one face is concave, and the other convex, but the degree of concavity and convexity varies considerably, and the working-edge may be gouge-like, or almost straight. However, on one side of the working-edge there is always a pronounced bevel. In some forms there is no concavity at the working-end, but in these the bevel on one side is larger than that of the other, so that even in these implements the 'scooping' effect is probably not interfered with. This bevel is a constant feature in all forms of the stone adze of the 'scoop-like' type in whatever part of the world they are made and used, and it seems likely that its function is to assist the sharp stone edge into and through the wood in a scooping-out action and effect.

Miss Beatrice Blackwood collected a series of polished stone adzes during her stay among the Nauti Tribe, Upper Watut River, Morobe District, New Guinea, in 1936–7. These adzes show much variation in the manufacture of the working-edge. In Miss Blackwood's Paper (1950) the various types are discussed and illustrated, figures and diagrams explain the curves of the working-edge, and the use of these tools is detailed in the text and shown by photographs taken on the spot by the author. Variations in adze-forms are likely to be mainly due to the nature of the work for which the implement is intended, but they may be partly due also to individual preferences, since each man makes his own tool. Again, differences may be affected by the type of stone chosen for the blade (Blackwood, 1950). The fluting effect of these adzes on the wood can be seen in a photograph of a tree cut by a stone adze, taken by Miss Blackwood.

7. The Australian aboriginal stone axe is hafted with the line of the edge parallel to the line of the haft, as in the modern iron axe, and it is also used unhafted in the hand. Judging from the specimens examined in the Pitt Rivers Museum, its section is thick as compared with the New Guinea adzes described above, but its working-edge is similar with regard to the bevel on one side of the edge, and flattening, &c., on the other, and its blows must have been delivered to have the same 'scooping' effect.

8. The Mount Hagen, New Guinea, polished-stone axes, of beautiful manufacture, in the Museum, are hafted with the line of the edge parallel to the line of the haft, modern axe fashion. Four of these, probably ceremonial axes, have fine bevel edges; one, probably a working tool, has a steep, thick bevel edge.

From Polynesia, the Museum has adzes with oblique, and sometimes extremely steep chisel edges. Some are small, others very large and massive. In their general form these Polynesian adzes resemble the modern iron adze rather than the Neolithic-type adzes discussed in note 6. Buck, 1930, pp. 332–3,

writing on Samoan material culture, describes 'an adze hafted sideways . . . and used for felling a tree'. Thus there are considerable variations in form possible in these wood-working tools, but the scoop-like type described in note 6 is found among many peoples and in many parts of the world. In Perak, Malaya, and from the Irrawaddy, there are adzes similar in form to the Polynesian type, having similar steep and oblique chisel edges.

9. There are some flaked chert hoe-blades from Missouri and Illinois in the Museum. For full information as to the work-sites and manufacture of these implements, see Holmes, 1919, chapter xvi, pp. 187–94. The working-end of these implements differs in construction from that of the wood-working stone-adze, but the flaking and shaping of the tool as a whole is similar in manufacturing technique to the blocking out of the flaked stone adze.

Chapter II

TECHNICAL PROBLEMS

FROM a manufacturing point of view, the four flaked-flint implements under discussion confront the worker with these preliminary problems:

1. To find nodules or pieces of raw material suitable in size and shape for the implement required, or to work a nodule or piece down to the requisite size and shape, or to strike a piece of the right size and shape from a block of siliceous stone, i.e. a core.

Solution. By experimental work and by the search for, and knowledge of, raw material. Technical advance along these lines led eventually in Europe and America to mining for the best seams of flint and other siliceous stone, and to advance in core technique in all areas.

2. To shape the implement and control its section by striking off flakes from the sides (lateral margins) that will carry across both faces of the piece of stone that is to be worked into the implement.

Solution. The cross-flaking can, with the hammer-stone, only be solved by the use of flaking-platforms prepared along the lateral margins of the implement, and this is the line of development in the technique of the hard hammer-stone.

Secondary problems affecting the worker may be listed as follows:

1. The manufacture of a section-taper, and the formation of the business-end[1] of the implement.

Solution. The assistance of the prepared flaking-platforms in the course of the specialization and development of the implement.

2. The problem of straightening and sharpening the edge of flat-sectioned cutting and piercing implements made from flaked flint.

Solution. The invention of pressure-flaking.

[1] In the flaked-stone adze, the gouge-like working-end needs skilful and accurate flaking-work. The bevel on the 'under-side' of the gouge-edge must be first formed, and then from a prepared platform along this margin the formation of the gouge-hollow must be carried out by a series of flakes converging fan-fashion on the median line of the implement. This fan-like pattern of the flakes forming the working-end of an adze can be very well seen in a large flaked-flint adze from Eastbourne (Fig. 2) in the collection of the writer, given by Professor A. S. Barnes. Experimentally it was found that the fan-flaking with its convergent pattern came naturally when the corners at each wing of the working-edge were rounded prior to the formation of the gouge-hollow. In the Stone Age implement a modified-gouge end with rounded wings is the usual pattern, and is evidently the most effective shape for wood-working.

3. The problems of shallow-flaking, ripple-flaking, and notching that arose in later Stone Age times with increase in knowledge and skill in stone-work, the fitting of the implement to a wooden haft, and the urge for sheer artistry in the mind of the worker.

Solutions. Shallow-flaking could be obtained by hammers of a material softer than the hard hammer-stone, and these experiments may have begun early (see baton-work with wood, bone, &c., discussed in Chapter VII), or follow on the discovery of pressure-flaking, and accompany the use of bone, &c., in the diffuse-bulb techniques (see Chapter VII) of the European later Palaeolithic period.

Ripple-flaking. Further refinements in shallow-flaking and ripple-flaking were met by the invention of the hammer-and-punch and pressure-by-impulsion (see pp. 84–87), probably as a sequel to the invention of pressure-work. Fluted cores of the French Solutrean period in the Pitt Rivers Museum suggest the development of these techniques for *core-work* at that time and place, unless the cores are the result of soft-hammer techniques (see pp. 51–52). But certainly ripple-work in *implement* manufacture is characteristic of the Late Prehistoric Stone Age in Europe and Egypt, and in the advanced flaking-work of the American Indian. Fluted cores from which long ribbon-like flakes have been pushed or struck off are characteristic of the Late Stone Age in Europe, the Middle East, and India, and in comparatively recent times have been produced by the Aztec Indians of ancient Mexico. Ripple-work was by some peoples in Late Stone Age times brought to perfection in implement manufacture with the assistance of surfaces prepared by grinding.[1]

Notching. When in some areas and in later Stone Age times, knife, spear, and arrow-head were notched so that they could be lashed to wooden shafts and handles, shallow-notching was made possible by pressure-flaking, and deep-notching by hammer-and-punch.[2]

[1] See Predynastic Egyptian ripple-flaked chert knives, and references in Sir John Evans, 1897, pp. 42–43.

[2] For discussion and references to literature, see Knowles, F. H. S., 1944.

Chapter III

TECHNICAL DEVELOPMENT IN THE MANUFACTURE OF THE FLINT AXE AND CORE

The Flaking-Platform

A FLAKING-PLATFORM may be defined as any area upon a nodule or piece of flint from which a flake can be detached by striking, or, in later industries, by indirect-percussion or pressure.

In the hammer-stone technique platforms may be:

1. *Natural.* An area on a piece of flint (it may be simply a prominence on a nodule, or a flattened edge of a pebble, that makes with the face to be flaked an angle, not too obtuse or acute) at which a flake can be struck off from the working-face, i.e. the face being flaked.

2. *Artificial.* This is an area flattened by one or more flaking-blows, on one face of the piece being worked into an implement or core, at such an angle with the face to be flaked (neither too obtuse nor too acute) that a flake can be struck off the working-face so as to shape the implement or obtain a needed flake from a core. In a form characteristic of Neolithic-type and modern Brandon cores, the platform is flat, and formed by a 'quartering' blow that divides the flint block into suitably shaped pieces. In this form it truly is a 'platform'. But in many cases the platform corresponds rather to a striking area. For it may be formed by several flakes, as in the faceted-platforms of the 'tortoise'-type core technique (see pp. 47–48), or vary from the crest of a flake-ridge to the hollow of a flake-scar, or be formed by several flakes as in some of the one-or-two-platform cores of later Stone Age industries. It depends upon the worker's knowledge and intentions, and upon the shape of the piece of flint that forms the core, and the shape of flake he wishes to strike off.

Axe-manufacture, using a quartzite pebble as a Hammer: Crude Techniques.

Crude Technique no. 1, the alternate-platform hand-axe technique. Early stages in the development of 'axe' technique with the hard hammer-stone are suggested by the early crude cores of Clacton and Clacton-type[1] in

[1] For references to Clacton and Clacton-type cores, see Warren, 1921–2, p. 597; Chandler, 1928–9, p. 79; and Paterson, 1945, p. 1.

the Pitt Rivers Museum with a steep edge-flaking carried out round the block (Fig. 3), and by crude hand-axes (Fig. 4) in the collection that appear to have been formed by similar edge-flaking along the lateral margins of pebble, nodule, or piece of siliceous stone. This *edge-flaking* technique was carried out by the worker striking a flake from the lateral

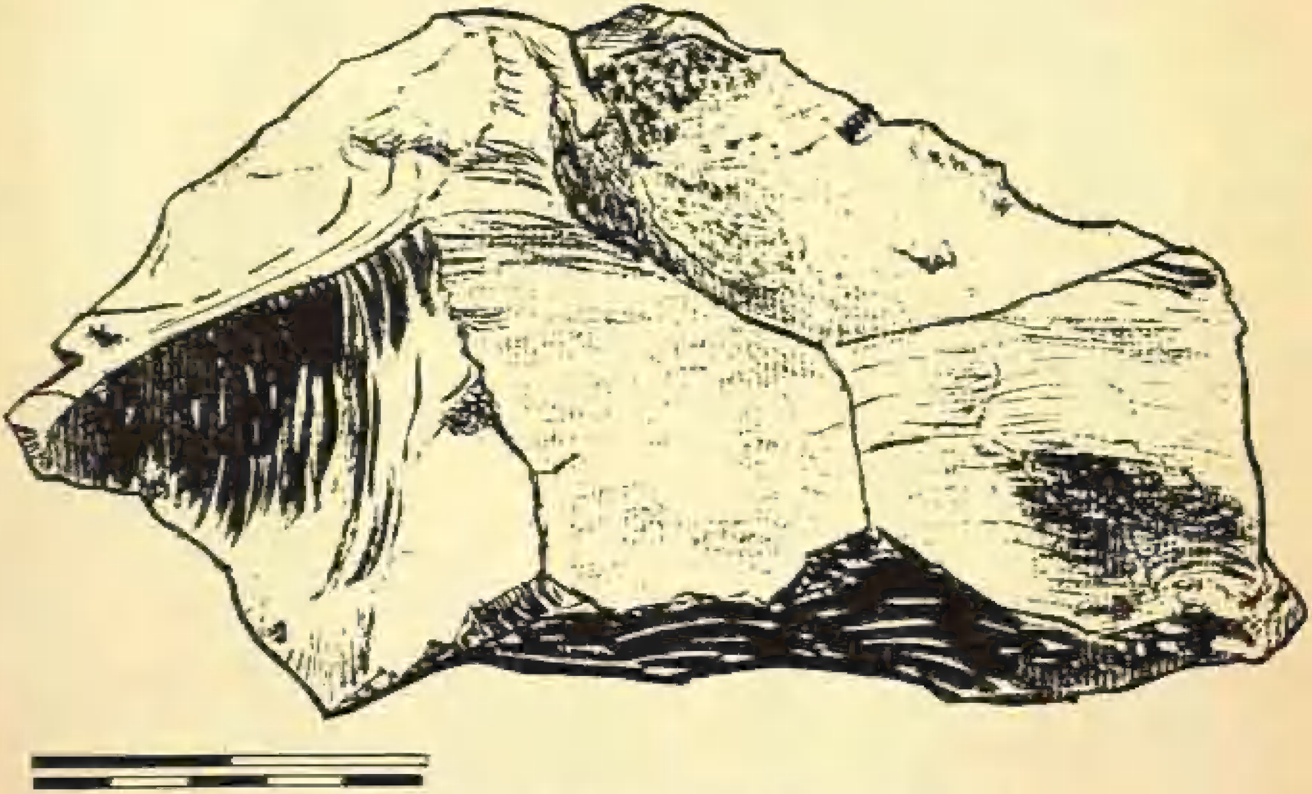

Fig. 3. Clacton-type core from the Boyne Hill Terrace found by A. D. Lacaille. See also pp. 46–47.

margin of pebble or piece across one face, and then by using the flake-scar as a platform, striking a flake off the opposite face, and so on round the implement. Hence the term 'alternate-platform'. This method leaves a sharp wavy edge.

Experimentally, the hammer-stone and alternate-platform technique produces wavy edges, unflaked areas of cortex in the middle of the implement, thickness of section, and a generally clumsy result. Such results are to be seen in two crude, and in appearance 'early' hand-axes in the Pitt Rivers Museum. The first is labelled 'Factory site above Nahun River, near E. London, S. Africa, d.d. H. Balfour 1910', and the second

'Race Course, Pietermaritzburg, d.d. C. G. Bliss 1927'. This latter is a crude specimen, made from a piece of tabular siliceous stone, and shaped, apparently, by alternate flaking.

Crude Technique no. 2, flaking across one face only, or part of one face of a pebble or nodule, by blows along the lateral margins. This method is to be seen in a small Palaeolithic hand-axe made from a flaked pebble from Swellenden, C.C., South Africa, given by Dr. van Heerden in 1929, in a pebble Palaeolith from Biddenham gravels, Bedfordshire, collected by the writer in 1909, and in the sharpening of the ends of Tasmanian flaked-pebble picks or choppers in the Westlake collection in the Museum. Uniface and semi-uniface axes or choppers made in this way, but often of very fine workmanship, were made by the former aboriginal inhabitants of Kangaroo Island, South Australia. Specimens presented by Professor A. S. Barnes and Lieutenant H. M. Cooper are in the Museum, and the implements are described and figured by Cooper, 1943.

Fig. 4. Palaeolithic hand-axe, Egypt, showing alternate-platform flaking. C. G. Seligman coll. 1940.12.752*b*. Drawn by I. M. Allen. *Scale 1/1*

As a matter of fact, this technique of flaking across one face is the preliminary stage in the manufacture of an axe, by the prepared-platform method, from a flattened pebble or nodule, and a fine flaking-pattern can be obtained by a skilled worker. Thus these Australian implements *may* be the work of a people who knew all about the manufacture of biface implements by the prepared-platform method, but preferred this simpler method because the implements so produced did the work required. This argument would apply also to the Palaeoliths and to the Tasmanian picks noted above, but the work on them is so very much cruder than that of the Kangaroo Islanders that it suggests want of technical knowledge rather than purposeful crudity.

A further example of native edge-flaking technique may be seen in a Bushman chopper in the

E. J. Dunn collection in the Museum (cat. 1940.10.9, D. 11, V. 8). This implement is made from a greenish-coloured pebble of a coarse-grained rock. It has been crudely edge-flaked, mainly on one face. It is figured in Dunn 1931, Plate V, no. 8.

Crude Technique no. 3, flaking from the edges of one face only of a massive flake. This method is to be seen in a Palaeolith from a gravel-pit near Bedford, collected by the writer in 1904, and now in the Pitt Rivers Museum. The implement has been made from a flake in which only the non-bulbar face has been flaked. Two Bushman choppers in the E. J. Dunn collection in the Museum are made by a rather similar edge-flaking technique. One (cat. 1940.10.9, D. 9, V. 5) is made from a large piece or massive flake of quartzite; one face is unflaked, the other appears to have been crudely flaked, resulting in a high median ridge and thick triangular section. The other (cat. 1940.10.9, D. 30, V. 3) appears to have been made from a piece of quartzite; the unflaked face is the outer surface of the pebble or boulder from which the piece was obtained; the flaked face runs to a high median ridge, and a thick and more or less triangular section is thus formed. Both choppers are illustrated in Dunn, 1931, Plate V, nos. 5 and 3.

Besides the alternate-platform method, then, there were two other variant methods, technically crude, but efficient in sharpening pebble or piece into an edged and pointed implement. In Palaeolithic times numbers 2 and 3 may have been alternative techniques, or simply used at times or by workers along with the alternate-platform method, but examples of the two variant methods are rare among the hand-axes in the Pitt Rivers Museum. It is very interesting to see that such crude and 'early' methods were employed by the native stone-worker within recent times, yet these methods evidently produced implements that were adequate for the purpose for which they were intended.

Technical Difficulties

The modern experimental worker finds three difficulties in making a flint axe, and these difficulties must have equally confronted the early stone-worker.

1. The impossibility of flaking from a square edge, such as is found on the broken margins of tabular flint (i.e. thin continuous seams to be sometimes seen crossing chalk quarry faces), and probably also in places on flattened irregularly shaped nodules.

2. The difficulty of flaking away steep and deep margins, rounded or irregular, such as may be found on large irregularly shaped nodules.

3. The impossibility of flaking properly by a blow directly on to a sharp edge, and the difficulties in cross-flaking a biface by blows 'off' the edges, owing to the thick short flakes produced by this method (alternate-platform technique).

Solutions Found Experimentally

1. A square edge[1] must be trimmed away by alternate-platform flaking, for a direct blow only drives in and breaks up the flint. The worker starts therefore at a corner. One blow takes the corner away at a slant. Then he uses the scar so formed as a platform for the next blow to take away a piece of the opposite edge, and thus gradually criss-crosses the square edge away to leave in its place a sharp wavy edge. This technique is useful at any time or place, for it may be used to remove a square or abrupt edge in axe- or arrow-head manufacture, so that although it is 'early' in technique as far as core and hand-axe are concerned, it might be employed, where necessary, at any date.

2. Much the same method as the above must be used to reduce the deep margins of large and irregularly shaped nodules. A flattened or thin place must be found along the margin, a flake struck off at a slant, its scar used as a platform, and the margin alternately flaked away as already described for dealing with a square edge.

An example might be noted here of the hand-axe (cat. 1947.8.16 in the Museum), where the worker has taken not one flake from a platform provided by a previous flake-scar, but several flakes. This is common sense, for where the platform is suitable, why turn the hand-axe as long as flakes can be obtained from the platform?

It is just this deviation that might well be the first step to the realization

[1] Tabular flint running in a continuous seam breaks up with square edges. This type of flint seems to have been little used by the stone-worker in this country, for there is only one Palaeolithic hand-axe in the Pitt Rivers collections that can be ascribed definitely to this form of material. Neolithic man at Cissbury appears also to have disregarded it as material for axe-manufacture, to judge from the material in the Museum. But some hand-axes from South Africa in the collections suggest the use there of thin seams of siliceous stone: in one from the Race Course, Pietermaritzburg, given by C. G. Bliss in 1927, a piece of the square edge of the tabular material is present, unflaked. It may depend on local circumstances, accessibility, or reliability in manufacture, as to whether this form of flint was used or not. The large Clacton-type core from the Boyne Hill Terrace found by Mr. A. D. Lacaille is made from a large flattened *nodule* of very irregular shape and thickness. The Museum has a cast (cat. 1941.11.4) made and presented by Professor A. S. Barnes (Fig. 3).

that a suitably prepared platform was an advantage not for one flake only, but for a whole series of flakes, and so lead on to the purposeful preparation of a long marginal flaking-platform.

FIG. 5. Unfinished Palaeolithic ovate axe, showing part of carefully prepared flaking-platform or 'turned edge'. To see the flaking-platform to the best advantage, hold the page flat with the edge near to the eyes, and look along the length of the implement. Downham, Suffolk, J. W. Flower coll., 1864. Drawn by I. M. Allen. *Scale 1/1.*

3. If the worker tries to flake across the unflaked face of the 'uniface' from the partially rounded, partially sharp edges left by Crude Technique no. 2, or across the faces of a flake from its sharp margins as in Crude Technique no. 3, he will find that his blows only break in on the edges and at best only produce short clumsy flakes that do not travel across the unflaked areas.

It is not until he has found that the solution lies in preparing a platform along these edges (Fig. 5, also Fig. 18) *for his flaking-blows that he can obtain long flakes that will run across (cross-flake) his implement to the mid-line or farther.*

This technical advance will lead him:

1. To form platforms along the margins of the half-flaked nodule or pebble so that he is able completely to cross-flake the unflaked face.

2. When he has trimmed away a square edge, to form a marginal flaking-platform to deal with the sharp edge formed by his first flaking.

3. When flaking from the edges of a flake across the flake-face, first to prepare marginal platforms along the edges at a suitable 'flaking-angle'.

In a study of the technique of arrow-head manufacture (Knowles, F. H. S., 1944), the writer has termed the prepared marginal flaking-platform a 'turned edge', because the lateral margin or edge of a flaked implement is 'turned', i.e. blunted by flaking, so as to 'set' it at the correct slant or slope to form a flaking-platform for the cross-flaking process.

The Developed Technique of Axe-Manufacture

In axe-manufacture, as in arrow-head manufacture, the 'turned edges',

i.e. the prepared marginal flaking-platforms, will enable the worker to cross-flake both faces of his axe and to thin and shape its section.

In a flat pebble or nodule a series of blows along the rounded lateral margins will serve to cross-flake one face; next, a series of light blows along the edges so formed will 'blunt' the edges and form marginal platforms from which a further series of blows will cross-flake the unflaked

FIG. 6. Flaking a flint nodule with a quartzite hammer-stone.

face (Figs. 6 and 7). In a square-edged piece, the square-edge must be first trimmed away as explained in Experimental Solution no. 1, and a 'turned edge' then formed along the lateral margins for the cross-flaking process.

An irregularly shaped and steep-margined nodule must first be treated in much the same way. See Experimental Solution no. 2. Then 'turned edges' must be formed for the cross-flaking process.

If the worker is using a large flake to make into an axe, then he must 'turn the edges' for the cross-flaking blows, as in arrow-head manufacture from a smaller flake. See the descriptive figures in the writer's paper on arrow head manufacture (Knowles, F. H. S., 1944) and Figs. 8–10.

If a roughed out, suitably shaped piece is used, then the margins must be trimmed to allow the preparation of the flaking-platforms or turned edges.

Diagrammatic sectional view

1st stage
Flake across one face (A) striking from the cortex-covered lateral margins.

2nd stage
Turn the edges

3rd stage
Flake the other face (B) from the flaking-platforms formed along the lateral margins

Final Section

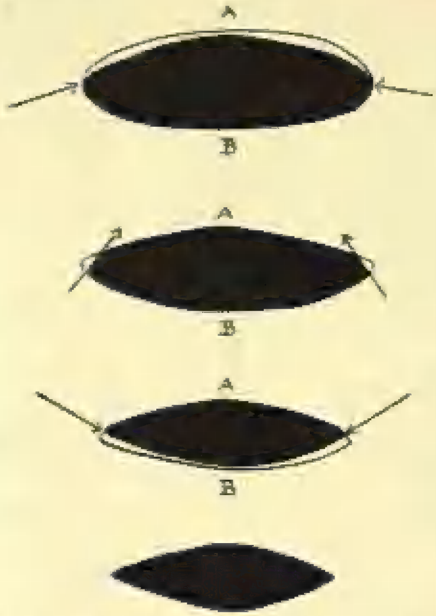

Fig. 7. Manufacture of an axe from a nodule by quartzite hammer-stone.

Fig. 8. Flaking from a core with the quartzite hammer-stone. (Clacton-type and 'tortoise'-type cores must be tilted towards the hammer in the same manner in order to detach the flake. (See definition of flaking-platform, p. 33).

Diagrammatic sectional View

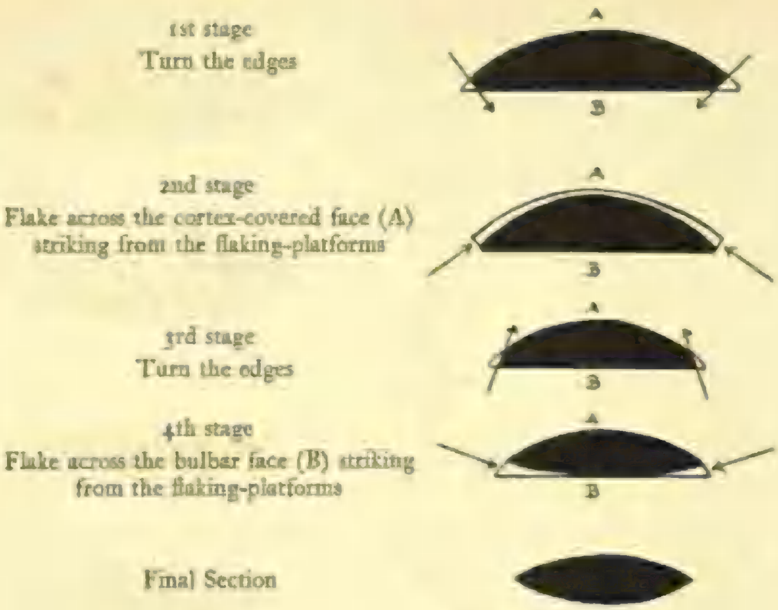

Fig. 9. Manufacture of an axe from a large flake.

Fig. 10. Flaking from the 'turned edge', i.e. the prepared flaking-platform, with a quartzite hammer-stone.

It is never easy. The nodule or piece must be of suitable shape, all blows must be correctly judged in strength and accuracy, the axe-in-making must be free from flaws and inclusions that would affect the run of the flakes. Much skill is needed and knowledge of the material. But the prepared-marginal-platform technique made possible the manufacture of the beautifully made implements produced by the Stone Age craftsmen.

Technical Stages in the Manufacture of a Palaeolithic Biface Flint Hand-axe, and a Neolithic Flint Adze, with a Quartzite Pebble as Hammer-stone, based on Experimental Work, 1

Raw Material. A suitably shaped nodule, a large flake struck from a block, or a shaped piece of flint.

Palaeolithic Flint Hand-axe

Stage 1. Preliminary trimming and shaping the piece, if required by the form of the raw material. See Note 1 below, on p. 43.

Shaping, and forming the section, by cross-flaking (see Note 2 below) both faces of the nodule, flake, or piece. This is carried out by blows along the lateral margins with the aid of prepared-platforms (see p. 38).

Stage 2. Straightening and correcting edge, removing spurs, and general trimming.

Neolithic Flint Adze

Stage 1. Preliminary trimming and shaping the piece, if required by the form of the raw material. See Note 1 below, on p. 43.

Shaping, and forming the section, by cross-flaking (see Note 2 below) both faces of the nodule, flake, or piece. This is carried out by blows along the lateral margins with the aid of prepared-platforms (see p. 38).

Stage 2. A further series of flakes along the lateral margins to trim them, and to prepare the tool for its wooden haft. This second flaking series often overlies and confuses the prior flaking-pattern.

Stage 3. Forming, by flaking, the working-end and edge of the adze. See Note 1 on p. 31.

Stage 4. Grinding, if this technique is carried out, either wholly or in part, as a finish to the implement, or as a smooth polish or finish to the working-end and edge.

Notes

1. With a suitably shaped nodule, the worker could start at once with the cross-flaking process.

2. Cross-flaking, i.e. flakes struck from the lateral margins that run across the face being flaked to the mid-line or farther.

Core Technique, 1

Similar to axe-technique problems are those involved in the change-over from the Clacton-type core to the 'tortoise'-type core, for the worker needs the knowledge of platform-preparation in order to shape the type of flake that he requires on one face of his core, and then form a striking-platform that will enable him to remove it from the core by one well-directed blow. In the 'tortoise'-type core technique such a platform is known as a prepared-platform or a faceted-platform, the latter term meaning that the series of blows that make the platform often, though not always, leaves small facets on the flake-platform and on the core.

To judge from some crude Palaeolithic cores in the Pitt Rivers Museum, advance in technique has taken place, (1) when the worker wished to detach symmetrical flakes from the working-face of his core, as in the single mid-ridged flake in the Clacton industry, and (2) when he found that by one or more blows at the base of the flake he wished to detach, he could make a slanting platform that would enable his final blow to take a long flake off, because by the angle so formed his blow would drive well across the working-face of the core.

A blow on the trimmed butt of a hand-axe directed towards the pointed end would produce a large wide flake to thin the section. This could give the worker the idea of making a similar core to produce a similar flake, i.e. a 'tortoise'-core. Advance in technique in core and axe manufacture are likely to have been parallel, since their problems are alike. The problems of core and implement work appear always to be interrelated, as may be seen in the fluted cores and fluted implements of the later Stone Age.

Axe Manufacture, 2

Technical evidence of the development of 'axe' manufacture. Clues to the course of development are presented by some Palaeolithic hand-axes in the Pitt Rivers Museum, either rejected in the process of manufacture, or with patches of the opening stages of the work not entirely obliterated by the final finishing touches, i.e. the secondary work. There are also in

the collections representative series of implements, finished and unfinished, from Neolithic English, Welsh, and Irish axe-making sites, also from a recent New Guinea factory site.

Technical Evidence from the Lower Palaeolithic

Examples of Lower Palaeolithic hand-axes in the Museum suggest that the knowledge of elaborate platform-preparation was arrived at by slow degrees, and that the earlier attempts consisted of crude and partial preparation of portions of the lateral margins of the implements. These examples cannot be arranged in any time-sequence, so that they must be considered only as interesting 'pointers' to a likely course of development.

The specimens in the Museum that demonstrate the stages in platform-preparation are the following:

1. Hand-axe labelled 'Unfinished Chellean implement (a failure), ?Swanscombe. Purch. 15.11.1927, Stevens'. This specimen shows a modified alternate-platform technique; several flakes appear to have been struck from one flake used as a platform.

2. Hand-axe labelled 'Somme Valley, France, A. M. Bell coll., Purch. 1900'. Several flakes form a wide flaking-platform along one margin of the butt.

3. Hand-axe labelled 'England, 1947.8.16, d.d. Sir F. Knowles'. This is a hand-axe in course of manufacture from a small nodule. Along one lateral margin *several* flakes form a continuous platform from which flakes have been struck across one face; on the other margin *one* large flake forms a platform from which several flakes have been struck to meet the above-mentioned cross-flakes. The platformed face has not been struck.

4. A pear-shaped Acheulean-type hand-axe from Kenya (1947.2.459, d.d. L. S. B. Leakey) has a boldly, though rather crudely, flaked platform extending across one of its lateral margins, from which flakes have been struck across one of its faces.

5. A finely made Acheulean-type ovate hand-axe labelled 'Downham, Suffolk, 1864, J. W. Flower coll.' shows on part of its margin the remains of a finely chipped flaking-platform, which would suggest that at the time this axe was made the worker knew all about the advantages of a careful preparation of the lateral margins of his hand-axe, so as to be able to cross-flake it successfully and control the section (Fig. 5).

Technical Evidence from the Upper Palaeolithic

In the French and Palestinian Upper Palaeolithic collections in the Museum there are no large thick bifaces, so that no technical evidence is available for this period.

Technical Evidence from the Mesolithic

1. In the Museum there is a small 'axe' labelled 'Denmark, Kitchen Midden,

P.R. coll. 957'. This implement is flaked across one face only from two crudely flaked platforms running along both lateral margins. The working-edge is formed by a cross-flake (tranchet-technique). Other similar types of implements in the collection are made by similar technical methods.

2. An implement labelled 'Mt. Carmel, Palestine, Mugharet el Wad, Layer B.2 (Lower Natufian), d.d. B.S.A.J., 1932' is a biface (?chopper) resembling in shape and technique a small hand-axe, although crudely made and thick in section compared with a good Palaeolith.

Technical Evidence from the Neolithic

The Museum has representative collections from the English site at Cissbury. See Fox, A. Lane, 1876.

Collections from the Welsh site at Craig-Lwyd. See Warren, 1919, p. 342.

Collections from the Irish site at Cushendall. See Knowles, W. J., 1903, p. 360.

On all these factory sites the technique of the prepared platform has been used in the manufacture of stone adzes. Specimens from the sites that illustrate the technique are shown in a case in the Museum devoted to Axe Manufacture.

Technical Evidence from Modern Stone Age Peoples

The Museum has a series of specimens from an adze-making site on Woodlark Island, New Guinea (Seligman and Strong, 1906, p. 348). The prepared-platform technique was in use on this site, and examples to illustrate this are shown in the case on Axe Manufacture.

In both the Neolithic and Recent Stone Age factory sites notes above, the character of the flaking appears similar to that produced by a hard hammer-stone, and carefully prepared flaking-platforms were made along the lateral margins of the adzes in course of preparation. Among the Craig-Lwyd and Woodlark Island specimens there are two examples in which the worker has made use of a natural platform running along one lateral margin provided by the rock formation. The two specimens are identical in workmanship and appearance, even the colour and appearance of the siliceous stone being alike. In all these sites also technical knowledge is advanced, skill and craftsmanship supreme, and the worker, both prehistoric 'white' and modern 'black', turned out beautifully made and efficient tools.

Summary

It seems from the foregoing evidence, therefore, reasonable to presume that 'evolution' in hammer-stone technique proceeded from the crude edge-flaking techniques of early times to the use of more elaborately prepared platforms, with a consequent improvement in cross-flaking,

section-shaping, and the preparation of the working-end in the adzes of later periods, and that this technique of the hammer-stone and marginally prepared platform was in use in widely separated geographical areas, and also within quite recent times.

FIG. 11. Clacton-type core, Stellenbosch. C.C.; d.d. H. Balfour, 1905.

Core Technique, 2

A study of Core Technique was undertaken by the writer for the Pitt Rivers Museum, and a classification of cores attempted. The results are shown in the Core Exhibition in the Upper Gallery. The summary given here will explain the suggested course of development.

Clacton-type Cores

1. The earliest type of core represented in the collections is the alternate-platform core (see p. 33 and Figs. 3 and 11). Examples include type-specimens from Clacton presented by Mr. Hazzledine Warren, the cast of a large Clacton-type core found by Mr. A. D. Lacaille in the

Boyne Terrace, made and presented by Professor A. S. Barnes, alternate-platform 'biconical' cores from South Africa, cores from the Palestinian Lower Palaeolithic of Mount Carmel, presented by Professor D. A. E. Garrod, and a few cores of this type collected by the writer from the Biddenham gravels.

To judge from these examples, the form of the material usually chosen for this technique was a piece or nodule of flattened shape. Flakes were struck from the margins of the piece of material by the alternate-platform method. In symmetrical cores the flaking was proceeded with round and round the piece until its flaking possibilities were exhausted, and the final reject state was likely to approach a biconical shape. In irregularly flattened material only part of the core may have afforded the required flakes, and the reject would then be of irregular form (chopper-cores?). Professor A. S. Barnes preferred the term alternate-platform cores, and the writer named them edge-flake cores.

'Tortoise'-type Cores (Figs. 12–14)

2. With the development of a more elaborately prepared platform the core technique evolved along the lines of the preparation of a symmetrical flake on one face of the core. In the skilfully designed 'tortoise'-core a platform was flaked all round the core in order to form on one face, by

FIG. 12. Technique of the manufacture of a 'tortoise'-core. Core and flake made with quartzite hammerstone by the author.

A. Flat platform
B. Sides
} approximate outline of the piece of flint from which the core was made.

C. First series of flakes shaping sides of core.
D. Second series of flakes shaping flake on the face of the core.
E. Flake forming the platform from which the flake on the face of the core is struck off.
F. Place struck by final blow detaching flake formed on the face of the core.

the next series of flakes, the flake-implement required by the worker. This flake-implement was then struck off the core by a blow on the part of the platform forming the base (bulbar-end) of the implement. By

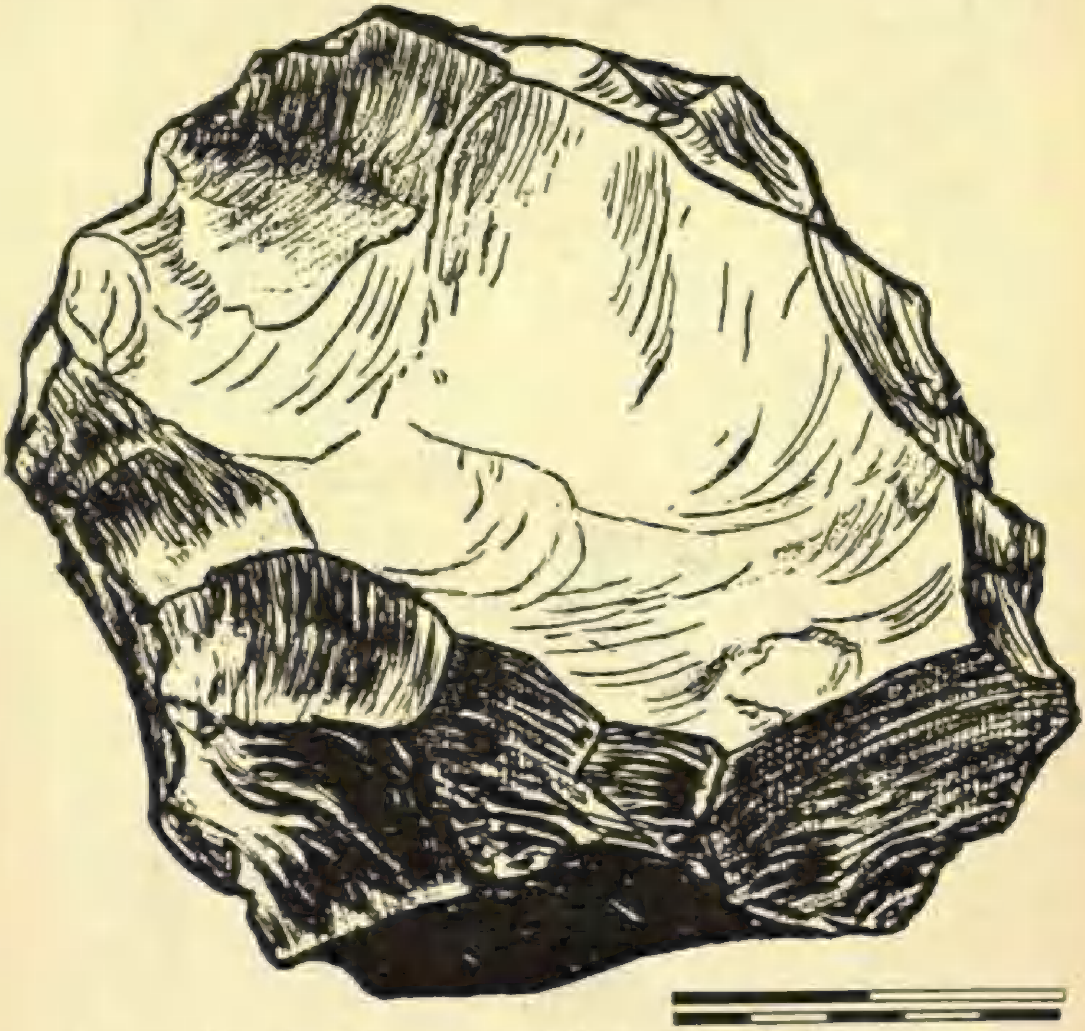

FIG. 13. 'Tortoise'- or Levallois-type core from Baker's Hole, Northfleet, Kent. James Cross coll. Purch. 1918.

differences in the shape and make of this type of core (but all with one underlying technical idea, i.e. the formation of the flake required on one face of the core) many different shapes of flake could be obtained by the worker. This type of core is characteristic of the Middle Palaeolithic period, and was termed a top-flake core by the writer, and a multiple-platform core by Professor Barnes.

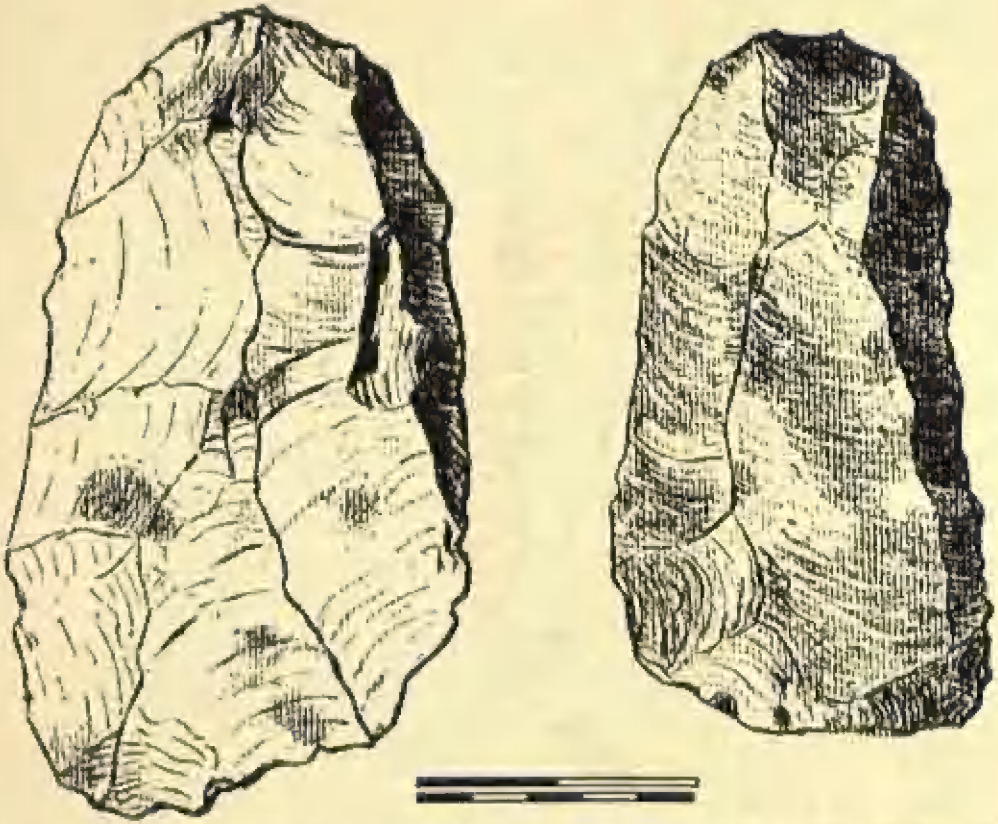

Fig. 14. Two flakes struck from 'tortoise'- or Levallois-type cores (the other sides are smooth flake-scars). James Cross coll. Purch. 1918.

Fig. 15. 'Modern'- or Brandon-type core, Grimes Graves, Suffolk; d.d. Rev. H. G. D. Kendall, 1920.

'Modern'-type Cores (Figs. 15, 16)

3. Somewhere between the Middle and Upper Palaeolithic period, the 'tortoise'-core technique was given up in favour of flaking from plain platforms, formed by one or more blows, down the sides of the core and all round the core where the shape permitted. This technique seems likely to have been developed from the 'tortoise'-type two-platform core, and

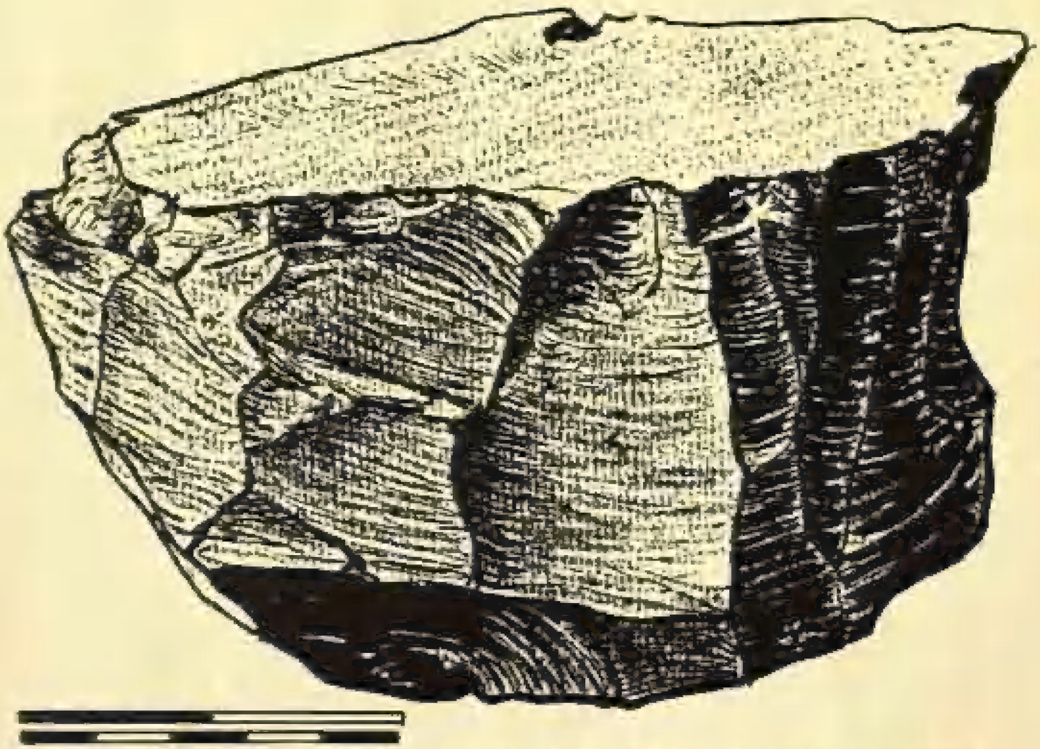

FIG. 16. 'Modern'-type core, quartzite, River Jordan, Brighton, Tasmania, Westlake coll.

from the preliminary stage in one type of 'tortoise'-core where a platform may be formed by flaking round the sides of a flat-topped piece of flint. These 'modern'-type cores were termed side-flake cores by the writer, and end-platform cores by Professor Barnes. They are found in the Museum collections from the Upper Palaeolithic, Mesolithic, and Neolithic, and are also the predominant type of core in the collections from the recent stone-working peoples of America, South Africa, Australia, and Tasmania. It is a simple and effective flaking-technique, and, with a platform made by one 'quartering' blow, is in use at the present day by the gun-flint knappers of Brandon in Suffolk.

'Modern'-type Cores with Diffuse-Bulb Pits

3a. In the Museum's Upper Palaeolithic collections appear cores that show shallow flaking and diffuse-bulb pits, and flakes that have diffuse-

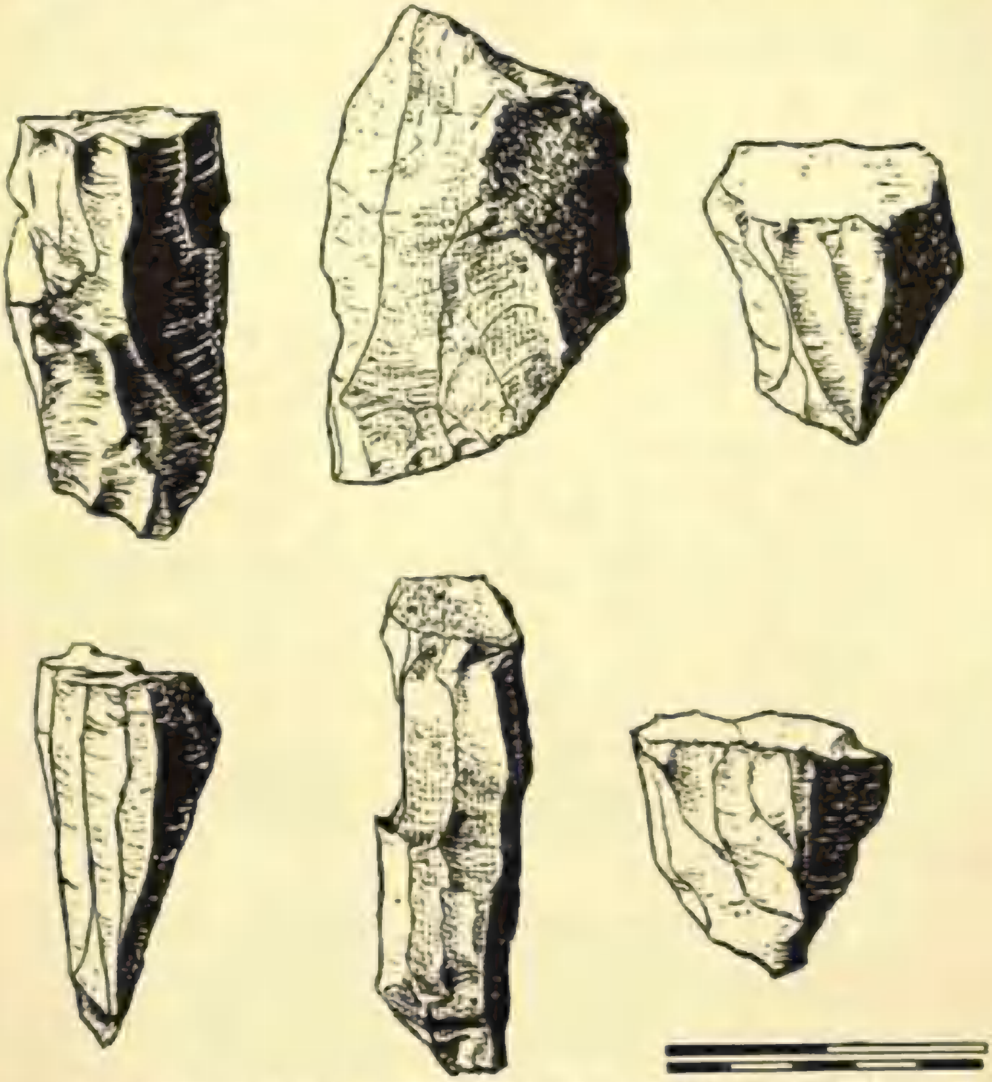

FIG. 17. Cores with shallow flaking and diffuse-bulb pits, Upper Palaeolithic.
Above: Badegoule, Solutrean; Palestine, Mugharet el Wad, Lower Aurignacian; Les Eyzies, Upper Palaeolithic.
Below: Grotte du Placard, Lower Magdalenian; Laussel, Upper Aurignacian; La Ferrassie, Aurignacian.

bulbs.[1] They occur in the collections from the Lower Middle Aurignacian of Palestine, from the Upper Aurignacian of the Dordogne, from

[1] For 'diffuse-bulbs' and 'soft-hammers' see Chapter VII.

the Solutrean of Badegoule, and from the French Lower Magdalenian (Fig. 17). These cores cannot have been the work of a hard hammer-stone, though they might be the work of a soft-hammer, for it would seem likely that by the time of the French Upper Palaeolithic, experiments with antler, bone, &c., would have shown the worker the advantage of hammer materials softer[1] than the hard hammer-stone. But in the Early Upper Palaeolithic of France comes the *Pressure-Flaking Technique*. It is complementary to the use of the hammer-stone, and is necessary for fine flaking-work. Its early use may be seen in the narrow-flaked working-end of Aurignacian nosed-scrapers. Thus the diffuse-bulbed cores might be explained by a likely development of hammer-stone work and pressure-flaking, i.e. by the use of *Hammer-and-Punch* and *Impulsive-Pressure*. For the modern experimenter finds that in pressure-flaking a strong 'jerk' is needed rather than a steady pressure. Professor A. P. Elkin's observations (see p. 89) show what the skilled hands of the Australian aboriginal stone-worker can do by unaided pressure. But with the urge to get off still longer pressure-flakes, it seems likely that some inventive Stone Age genius experimented with direct blows on the pressure-flaking tool in order to increase the force of the jerk. From this would naturally develop the techniques of hammer-and-punch, impulsive-pressure, and the combination of the two described by Catlin (see pp. 84–87).

Chipped and flaked platforms are often to be seen on cores flaked by diffuse-bulb methods. These cores are so prepared in order to seat the flaking-tool (see p. 75). In these cases, the worker's idea is completely different from that of a maker of a 'tortoise'-type core, although the platform is, nevertheless, a 'prepared' one.

[1] The writer, using a hard-wood 'handle' in experimental core-flaking, found the results disappointing; even though the 'baton' was weighted with lead, it had not the weight necessary to obtain flakes from the flint core. Professor Barnes, in the writer's presence, used a length of heavy antler, but only succeeded in striking broad thin flakes from the flint core, 'scaling' it rather than flaking it. Other forms of 'soft' hammers might give better results. A large and heavy antler-boss shaped and used like a hammer-stone might prove an efficient flaker.

Chapter IV

A. TECHNICAL DEVELOPMENT IN THE MANUFACTURE OF THE FLAKED-POINT USED AS SPEAR-HEAD, KNIFE, OR ARROW-HEAD

With certain exceptions, viz. bevel-edged knives, Egyptian ripple-flaked knives, and Danish flint daggers, the flaked spear-head, knife, and arrow-head differ but little, technically, save in size. The general likeness is shown by American Indian arrow-head-shaped and notched implements; only length and size distinguish between arrow-head, spear-head, and knife.

There are two main lines of descent in the development of the flaked-point, when considered from the point of view of the form of the material used and the technical methods employed:

I. The flaked-point made from a flake.
II. The flaked-point made from a piece of flint shaped from a seam or nodule.

I. The use of a plain pointed flake as a knife when fixed in a short wooden handle, or as a spear-head when attached to a long shaft, is common among all Stone Age peoples. The preparation of such a flake by secondary flaking-work in order to give it shape, symmetry, and a means for attachment to its handle (notching, or shaping the butt) follows in its development as a specialized form of implement. But with regard to the secondary work there is considerable freedom of choice and preference on the worker's part as to how far and to what extent the secondary work should go, whether the flake is better flaked across one face only, or on both faces, what shape is preferred, and how it should be hafted. Thus one has on the one hand the development or evolution of a plain flake to an artistically cross-flaked spear, knife, or arrow-head, and on the other hand the use, for choice, of a comparatively crude flake spear or knife at a time or place where a finer product would seem more likely.

For the arrow-head, the use of a finely cross-flaked and symmetrical point seems to be general (exceptions are the tranchet arrow-head and the Bushman chip-edged arrow-point) at times and in areas where the

flint-pointed arrow was in use. This was presumably due to the need of symmetry for accurate shooting; otherwise a point with much less work on it would seem likely to be chosen for a weapon that was so often lost in use. At the same time the artistic feeling of the Stone Age craftsman must be taken into account; witness the care lavished on his fragile flaked spear-head by the Worora aboriginal (see p. 89).

If the use of wood, bone, or antler baton is postulated, then the cross-flaking of the flake to be used as a point, if not inherited by tradition, could follow on by simple developmental degrees. For the work of Professor A. S. Barnes, exhibited in the Pitt Rivers Museum, illustrates the ability of the baton to flake from an edge, and this technical advantage is discussed and illustrated by M. François Bordes, 1947. His work is further discussed on p. 63 of this paper.

But the cross-flaking of a flake by quartzite hammer-stone is a more complicated process, and needs the previous preparation of marginal flaking-platforms along the flake's edges (Fig. 18, also Fig. 10). In the hard hammer-stone technique we are therefore faced, from a developmental point of view, with three possible lines of descent.

1. *By tradition.* Since the technique of cross-flaking with a hard hammer-stone had been developed in hand-axe manufacture in Lower Palaeolithic times (see Chapter III), then it would seem the natural course that this knowledge should be passed on down by tradition and used in later times to manufacture with the hammer-stone the finer biface implements such as the spear, knife, and arrow-head.

2. *By development.* Proceeding from one step to another; shaping the flake, cross-flaking part of it (finding out the necessity of a marginal flaking-platform); cross-flaking one face only (using one pair of marginally prepared platforms); then the final cross-flaking of the other face (using two pairs of prepared platforms), thus turning the flake into a biface implement.

3. *By rediscovery.* The prepared-platform technique has been rediscovered by some modern Brandon workers, as may be seen from arrow-heads in the Pitt Rivers Museum made by Mr. Fred Snare and Mr. William Spalding.[1] Thus it is quite possible that it should similarly have been arrived at by the earlier worker when he wished to cross-flake his flint point, either to make it more efficient, or to satisfy his artistic sense.

[1] The results they achieved show plainly that they understood the technique, but they kept it a secret. The prepared-platform technique was independently discovered through experiments by the author, and the first literate presentation was made by him in 1944. See Knowles, F. H. S., 1944.—*Editors.*

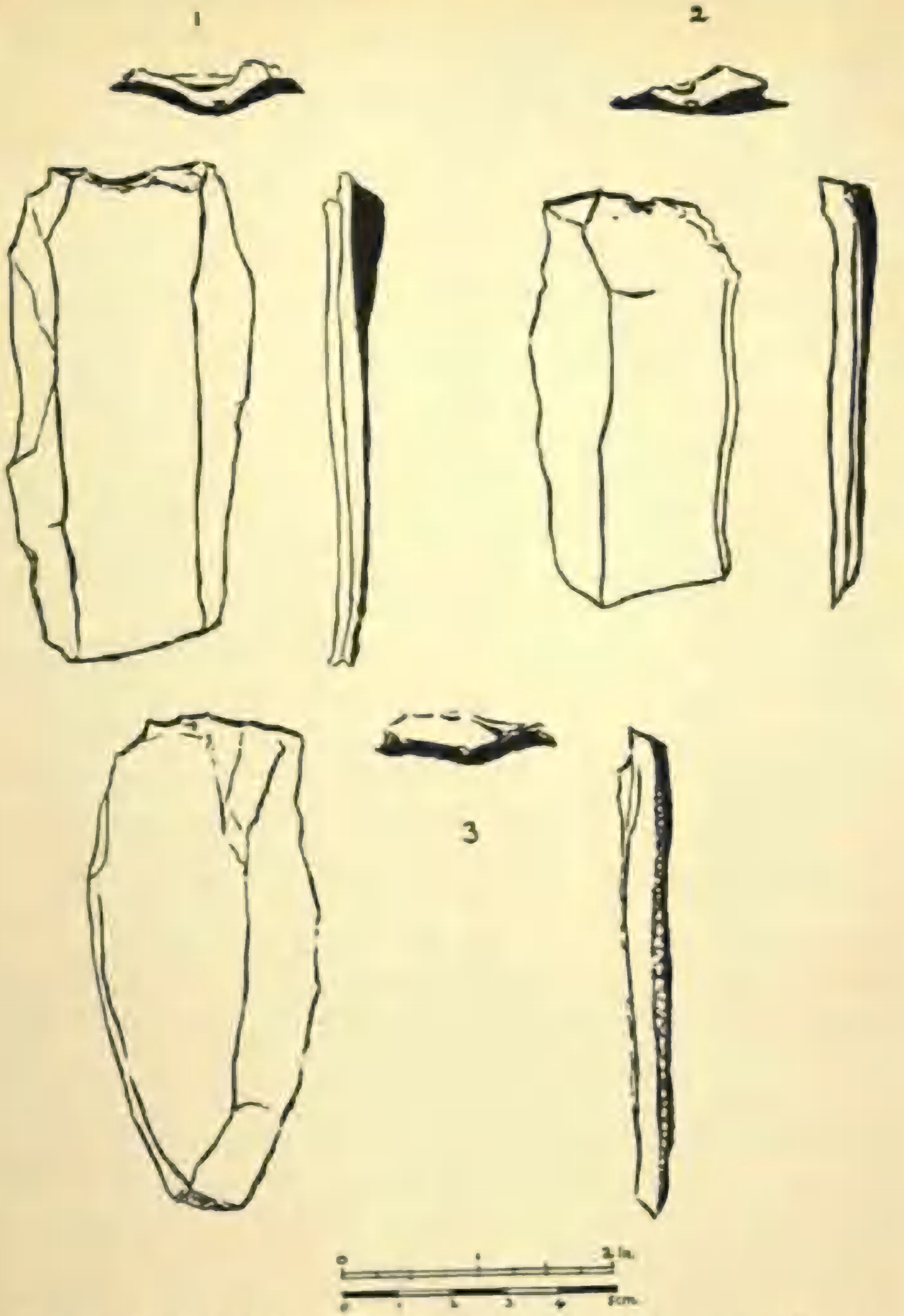

FIG. 18. Three double-ridged flakes struck by the writer with a quartzite hammer-stone. No. 3 shows the 'turned edge', or the prepared marginal platform along one edge.

So far as 'By development' is concerned, the following theoretical developmental series could be arranged from the collection of Kenya obsidian implements presented by Dr. L. S. B. Leakey.

Made from a pointed flake with single mid-ridge, *a*, *b*, *c*.
Type of flake used unknown, *d*, *e*, *f*.

a. A plain pointed flake with a mid-ridge either single or Y-shaped.
b. This type of flake dressed to a symmetrical shape and point.
c. The bulbar end thinned down by flaking.
d. Flaked across the non-bulbar face, a uniface.
e. The bulbar face trimmed, or partially cross-flaked.
f. The bulbar face completely cross-flaked, a biface.

Type *a* was made and used in early and late Stone Age times and in many parts of the world.

Type *b* was in use in the African Middle Stone Age, and is present among the specimens from the Levalloiso-Moustierian of Mount Carmel, given to the Museum by Professor D. A. E. Garrod.

Type *c* is found in Bambata Cave, Rhodesia. See Armstrong, 1931.

Type *d* is represented in the Museum by Pirri points from South Australia, by a South African leaf-shaped uniface given by Mr. J. A. Swan, and by a Solutrean uniface.

Type *e* is found in the Bambata Cave (Armstrong, 1931), and in Palestine, Et Tabun Cave, Mount Carmel, Lower Levalloiso-Moustierian, 'Point with bulbar face retouch', Garrod and Bate, 1937, Plate XXXVII, fig. 2.

Type *f* is represented in the Museum by European Upper Palaeolithic flaked-points, by African (Stillbay, &c.) flaked-points, by flaked-points of European Neolithic and Bronze Age times, and by flaked spear-heads, knives, and arrow-heads made by recent Stone Age peoples.

Nevertheless, a pointed single-midribbed flake is a very difficult subject for cross-flaking, because of the difficulty of flaking through and across the high central ridge. A symmetrical double-ridged flake, or a flattened piece of material, would be a much easier piece for the developmental process. Hence the plausible theoretical series outlined above may not have worked out in practice without the use by the worker after stage *c* of a double-ridged flake or a piece of thin tabular or seam material.

II. The manufacture of a flaked-point from a shaped piece of flint. Knife, spear-head, or arrow-head can be made from *thin seam siliceous material*. See Chapter X, p. 99. These implements may also be made from *thin flat nodules*. See Chapter X, p. 99. Indications of the use of this type of material are shown by patches of cortex on two specimens in the Museum, one a Danish flint knife, the other a ripple-flaked Egyptian chert knife. Or they may be made from *flattened pebbles*. See the quartzite

pebble industry at Piney Branch of Rock Creek, Washington, D.C., described by W. H. Holmes, 1919, Chapter XIII, pp. 159–72.

Using the hard hammer-stone technique, development would follow along the lines of axe-manufacture as reviewed in Chapter III, and reach its full development with technical methods based on the preparation of long marginal flaking-platforms (the turned-edge technique).

For seam material where the fracture is at right angles, alternate-flaking is first needed to prepare the edge for subsequent platform manufacture (see p. 37).

In nodules or pebbles of flattened shape, the natural platform provided by their sides is usually sufficient for the first cross-flaking (see p. 39).

Points can also be flaked down from a core or piece. See Professor A. P. Elkin's (1948) account of the manufacture of spear-heads by the Kimberley aborigines.

Difficulties in Judging the Course of Development

Any theory as to the likely course of technical development of the flaked-point is complicated by the type of hammer presumed to have been used, and by the form of the material used, which may possibly have been dependent upon the shape and quality of the raw material available.

Experimental Evidence

Experimentally, the aid of long marginally prepared flaking-platforms (the turned-edge technique) was found to be essential for the successful cross-flaking of points with a quartzite pebble as hammer (Knowles, F. H. S. 1944).

Evidence from the Modern Stone Age Worker

Professor A. P. Elkin (1948) shows that the long marginal flaking-platforms were in use among the Kimberley aboriginal spear-head makers, both for the preliminary hammer-stone work and for the finishing pressure-flaking process. American Indian point-flaking tools and accounts of their arrow-head manufacture are set forth in Chapter VIII of this paper, but there is need of a detailed explanation of the technical steps in the manufacture of their flaked-points.

Finishing Processes in the Manufacture of a Flaked-point

The recorded use of pressure-technique among recent native flaked-point makers has already been noted. And it is reasonable to suppose that

diffuse-bulb techniques such as hammer-and-punch and impulsive-pressure may have helped to produce large fluted and ripple-flaked implements (see pp. 60 f. and 74 f.). Thus these diffuse-bulb techniques also enter into the development and evolution of the flaked-point, and form a part of its technical history.

B. TECHNICAL VARIATIONS IN THE MANUFACTURE OF THE FLINT SPEAR-HEAD AND KNIFE AMONG MODERN STONE AGE PEOPLES

Australian Aborigines

In South Australia the plain pointed flake is used as a spear-head. But among the Kimberley District tribes most artistically flaked biface spear-heads are still made at the present day (Elkin, 1948). In South Australia the finely made Pirri point is found. It is flaked on one face only, and in its larger sizes may have been used as a spear-head (Campbell and Noone, 1943, p. 290 and Figs. 1–20). The date of its manufacture and use seems to be uncertain, but technically it represents an intermediate stage between the plain flake spear-head and the biface spear-head. Thus certainly two and possibly three 'stages in development' were in use at the same period of time among the same people. Professor A. P. Elkin, in a review of Knowles (1944), says of the spear-point manufacture by the aborigines of northern Kimberley, north-west Australia: 'It is recognized as a highly skilled work, and only members of the tribes who possess the craft attempt it' (Elkin, 1944–5, p. 168). Skill and choice both play their part in determining the type of implement made and used by the Stone Age worker.

Admiralty Islanders

Variations in technique are shown among the obsidian flake spear-heads and knives of the natives of the Admiralty Islands. These implements are made of plain flakes, single-ridged, double-ridged, or Y-shaped. But the Museum possesses some which have been shaped by marginal flaking, apparently percussion-flaking with a hard hammer-stone. This shaping may be done by steep flaking along a steep lateral margin, as in specimen no. 1944.12.123, or by small flakes struck from

along the edges to give a leaf-shaped form to the implement. The points of these flake-implements also are in some examples formed by what may have been a combination of percussion and pressure work, or perhaps sometimes by pressure alone. A specimen in the writer's collection is thinned down by blows down the non-bulbar face, and when taken from its haft, the platform and bulbar end was found to have been trimmed down by fine flaking to facilitate hafting. Thus the range of the Admiralty Islander's flaking knowledge was not restricted to obtaining these large and beautifully symmetrical flakes from an obsidian core, as might at first sight appear.

American Indians

Over the stone-working areas of America the beautifully made flaked-point, large spear-head and knife, or small arrow-head is a characteristic product of the craftsmen. But there are in the Museum some arrow-head-shaped implements made from flakes flaked across one face only (uni-face), and probably used as knives. Two of these are notched, one from Kentucky, the other from Illinois. A third, a plain specimen, comes from Arizona. Joyce (1932) describes a series of spear-heads of a form which appears to be typical of the Belize River. They are made from single-ridged flakes, the tangs worked out by percussion-flaking, and the edges and points sometimes trimmed by pressure-work (Joyce, 1932, Plate VI, Fig. 3). In length they are from 7 to 10 inches. There is, then, a considerable range in the technique of flint spear-head and knife manufacture by the American Indian, and variation in his choice of the form to be used.

Chapter V

FLAKING WITH A QUARTZITE PEBBLE AND OTHER HARD HAMMER-STONES

Two problems confront the inquirer: 1. What characters will show that a flaked-implement has been made with a hard hammer-stone? 2. What characters will show that a flaked-implement could not have been made with a hard hammer-stone?

With regard to problem no. 1, quartzite and other hard pebble work is, generally speaking, characterized by deep pits of percussion where the hammer-stone strikes the flint. When these are visible, it can reasonably be inferred that the implement was made with a hard hammer-stone in examples where the use of a metal hammer, which leaves equally deep pits, can be ruled out. But there are certain circumstances in which bulb-pits produced by the hard hammer-stone are 'semi-diffuse' in character (see p. 68). And the bulb-pits (percussion-pits) along the lateral margins of a flaked-implement are trimmed away if the implement's edge is straightened and sharpened, or if there is any secondary shaping work.

Another character of hard-pebble flaking-work is the somewhat rugged flake-scars on the surface of the implement made with this type of hammer. But it is possible that there may be variations according to the flaking quality of the material, and wear and tear may smooth the surface ridges of an implement.

From the foregoing considerations it will be seen that positive identification of hard hammer-work may often be a difficult matter, but that deep percussion-pits and rugged flake-scars indicate the use of a hard hammer.

With regard to problem no. 2, the following inferences are based upon experimental work. (1) There are certain flaked-implements in which there can be little doubt that diffuse-bulb techniques were used in their manufacture, viz. Egyptian Predynastic ripple-flaked chert knives (grinding was used to shape and prepare the surface for the ripple-flaking), fluted-flaked Danish flint daggers, and similarly flaked American Indian chert and obsidian knives. The characters from which may be deduced the use of diffuse-bulb techniques in the manufacture of these implements are the symmetry, length, narrowness, and shallowness of the

fine-flaking with which they have been finished, but it cannot be known whether or not the preliminary stages of their manufacture were carried out with the use of a hard hammer-stone. (2) In others, viz. the Solutrean large leaf-shaped flaked-points, and some American Indian flaked spear-heads and knives of large size, their breadth combined with their flatness of section and the smoothness of their flaking suggest either the use of 'soft' hammers or else some other diffuse-bulb techniques such as hammer-and-punch or flaking-staff. (3) Where flaking has been carried out at a high angle along the squared edges of Danish flint adzes, the use of a hammer-and-punch seems likely. (4) In Mexican obsidian cores, and in similarly flaked cores of siliceous material from other areas, the use of diffuse-bulb techniques may be inferred from the long, symmetrically narrow, and shallow flaking, from the high angle at which the final flakes have been detached before the cores have been discarded as rejects, and from the shallow bulb-pits on the cores. For the Mexican cores historical evidence records the use of a flaking-staff (see p. 85).

To sum up problem no. 2, narrow, symmetrical, and shallow flaking, and shallow symmetrical flaking at high angles, are both likely to be the work of diffuse-bulb techniques. Extensive experimental work is needed for a satisfactory solution of the problem.

This leads on to the next question. *What are the limitations in the usefulness of the hammer-stone?* There are two factors that must be taken into consideration when judging the value of the hard pebble hammer in flaking-work, first, the cross-flaking quality of the piece of stone that is being worked, and secondly, the skill of the flint-worker.

As for the first, the influence on successful flaking of the cross-flaking quality of the siliceous material has been discussed on pp. 17–18 of the writer's paper on arrow-head making (Knowles, F. H. S., 1944).

As for the second factor, the skill of the worker, the master-flakers who turned out the large thin flaked knives and daggers have long since disappeared, and it is they who could have best said how far they could rely on the pebble hammer, and when it was necessary to turn to some other technique to achieve their masterpieces. But the possibilities of the hard hammer are undoubtedly very considerable when it is used with the technique of the prepared-platform in flaked-implement manufacture.

Practical Advantages of the Quartzite Pebble Hammer-stone in Flaking-work

1. Its weight and toughness, and the fact that it is a good flint-flaker.

2. Its range of size, for large pebbles will break up flint blocks, and small pebbles of fine-quality stone will carry out fine-flaking in implement manufacture.

3. Its compact weight, which enables the hand of the worker to use it with great accuracy as a hammer.

4. Its convenient shape.

5. Its ubiquity.

Chapter VI

FLAKING WITH 'SOFT' HAMMERS

THE hammer-stone of quartzite or other hard rock is known to have been used by stone-working peoples, ancient and modern. Experimentally it has been found to be fully capable of producing, when combined with a prepared flaking-platform, a symmetrical and sharp-edged axe, arrow-head, spear, or knife of flaked stone.

Whether the use of the hard hammer-stone was the general rule, or whether there were other hammer-techniques in use in the manufacture of flaked-stone implements, is a very interesting question. The experimental work of Professor A. S. Barnes in this country, of Dr. L. S. B. Leakey[1] in Kenya, and of M. Léon Coutier and M. François Bordes in France, have shown that flaked implements can be made by means of wood, horn, bone, and antler batons and hammers. It has been proved that finely made implements can be produced by the technique of the baton hammer, and that the characteristics of this technique are the diffuse bulbs of the flakes struck off, and the long thin shape of the flakes themselves, with the consequent shallow flake-scars on the implement. Professor Barnes has also shown that hammers of soft stone produce diffuse bulbs. He has furthermore proved the efficacy of hammers of antler, bone, and especially horn in the flaking of glass, which is a brittle material compared with flint, but akin in its flaking quality to obsidian. Professor Barnes's technical series exhibited in the Pitt Rivers Museum shows why the wooden baton can flake from a sharp edge and produce a thin section without the use of the prepared-platform that is necessary in using the quartzite, and M. François Bordes (1947, especially Fig. 7, p. 13) explains and illustrates the baton technique.

These hammer-techniques are therefore possible substitutes for that of the quartzite hammer-stone, and though the quartzite will always have this advantage, that in its concentrated weight and toughness it can deal, in large sizes, with large masses of siliceous stone, while it is also capable of delicate work as a hammer in its smaller pebble sizes of fine-grained

[1] Dr. Leakey uses quartzite hammer-stones, animal mandibles, and lengths of horn, and has also experimented with limb bones of animals and wooden bars. Experience has led him to believe that it is the shape of the hammer and the method of contact with the flint or other stone which the shape imposes, rather than the material of which the hammer is made, that affects the kind of flake and bulb produced (Leakey, 1934, p. 60).

quality, yet the 'soft' hammer may remove less material when flaking because of the thin flakes and small bulbs that it produces. Certainly the occurrence of diffuse-bulb flakes in Stone Age Industry is a fact, and must be accounted for. In Chapter VII the question will be gone into in detail, and some conclusions arrived at on the possible use of soft-hammer techniques. Apart, however, from the use of a different hammer-technique altogether, viz. wooden batons, &c., in certain times and places, the technique of the hard hammer-stone was amplified by the use of techniques that would give a finer finish to the flaked-stone implement.

Hammers made of the indurated base of the antlers of deer and elk were in common use in some localities by the American Indian stone-worker for his lighter chipping work (Holmes, 1919, p. 284). They were used in the manufacture of large flaked-chert hoe-blades in a quarry in south Illinois.[1] They may also have been the secret of the Indian's success in the flaking of large thin blades of chert and obsidian.[2] In fact they would be likely to prove useful in cases where the jar and 'bite' of the quartzite pebble might be too strong for the material, or where very smooth and shallow flaking was required as a finish. Hammers such as these might equally well have been used in other areas and time-periods for fine flaking-work, especially when dealing with thin seam or nodular material of fine quality. If they were used in the hand, then their mode of use would be in line with the quartzite technique, for it would be simply using a hand hammer of a material softer than the stone worked.

[1] Holmes, 1919, p. 188 and Fig. 66. Also Holmes, p. 191: 'The chipping-hammers were roundish nodules or tough portions of chert chipped into convenient form'; and Holmes, p. 193: Chipping implements made of the base of deer antlers 'were probably used rather in the secondary trimming of the blades than in the roughing-out work'.

[2] Wilson, Thomas, 1899, p. 880. The following extract from Thomas Wilson's paper is interesting because it describes an American Indian flaking technique that *may* be based upon the use of an antler or other 'soft' hammer. On p. 913 he writes: 'Fig. 138 . . . is a marvel of flint chipping. Four and a quarter inches long and 1¾ inches wide, it is nowhere more than one-eighth of an inch in thickness. This is as thin as any specimen can be expected. . . . Some of the specimens from the Pacific Coast, figured in leaf-shaped, Class C, are as thin as this, but, as described, this was their natural thickness. They were separated from each other by a deposit of extraneous matter. This specimen is not of such formation. It has been wrought out of a solid block of flint, and was effected by those broad and thin flakes so often found, running from the edge, the point of pressure, to the center, widening into the form of a shell, and reducing the thickness of the implement almost as much at the center as at the edge. This system is the perfection of flint chipping. It shows a high degree of manual dexterity, and is one of the lost arts, for no workman known in historic times has been able to reproduce it.'

Chipping this implement from a 'solid block' does not seem a technical possibility, unless it was flaked from a core according to the Kimberley aboriginal method described by Professor A. P. Elkin in *Man*, October 1948. Otherwise a large flake or else a piece of seam material would appear to be a more probable 'nucleus'. But Wilson here well describes the character of a mode of flaking that produces wonderfully thin flaked-points, knives, &c., by the expert Indian stone-worker.

Pressure-work as a finishing technique is well known and was widely practised, and there is also its development, impulsive-pressure (see pp. 84–87). Both are adjuncts to percussion techniques. The use of hammer-and-punch has been recorded among modern native stone-workers, for instance among American Indians as noted by observers (see p. 84 for references), and its use in earlier times may be assumed, e.g. from the squared edges of Danish flaked flint axes.

To sum up then, there is the certainty of the use of the quartzite, and other hard-stone hammers, the certainty of its use being amplified by diffuse-bulb techniques, and the possibility of the use of hammers of a softer material as the essential working implement to take the place of the hard-stone hammer. Further discovery and study of flaking-sites of various areas and time-periods may throw some light on the problem, and even solve it should circumstances prove favourable to the preservation of material. For the finding of one of the 'soft' hammers would prove shape, material, and mode of use, as evidenced by the position of wear. But the earlier the site, the less likely such a discovery, for the very reason that the 'soft' hammer is by its nature so perishable.

Chapter VII

FLAKES AND HAMMERS

Hammers

1. The hard hammer is one of a material tougher and more resistant than the flint, e.g. quartzite pebble, other hard rocks, metal.

2. The soft hammer is one from a material softer and less resistant than the flint, e.g. wood, bone, antler, ivory.

Flakes

In working siliceous stone[1] of good flaking quality, when a blow is struck on a flat or flattened platform, as on a flat-platformed core, the following results usually occur in the flakes produced:

1. Flakes struck off by hard hammers are characterized by salient (i.e. large and prominent) bulbs, and by a cone of percussion (Fig. 19).

2. Flakes struck off by soft hammers are characterized by diffuse bulbs (i.e. flattened bulbs with oval curve and lip; see p. 67 and Fig. 20), and the absence of any cone of percussion.

Bulbs

1. Taking a characteristic method of flake production, the blow by a quartzite pebble on the inclined flat platform of a flint core: in a flake so produced an *unsymmetrical cone of percussion* is formed on the flake-platform, and the bulb so formed on the flake is usually *salient*, i.e. large and prominent, though variations in size occur. The *percussion-cone* is formed at the point of impact of the hard hammer, the side of the cone is visible on, and is a part of, the flake-bulb, and the broken up top of the cone is at the edge of the flake-platform. The cone, which forms the bulb, varies considerably in size and prominence. Its extreme form may be seen in Clacton-type flakes in which the cone is large and sometimes almost disengaged. In Professor A. S. Barnes's Technique Series in the Pitt Rivers Museum, specimen no. 1943.10.11 (Fig. 21) shows the unsymmetrical development of the cone of percussion in the formation of a flake with a salient bulb. Specimen no. 1943.10.12 (Fig. 22) shows at *A* the

[1] Flint, chert, jasper, obsidian, &c. For notes on the flaking of coarse siliceous stone and rocks see Lacaille, 1939.

unsymmetrical cone formed by the blow. Professor Barnes's note to 1943.10.11 runs:

'The first important phase in the formation of a flake with a salient bulb is as follows. In flaking from a core the platform is always inclined to the axis of the hammer at an acute angle which usually varies from about 70° to 87°. Consequently the hammer first comes into contact with the core at a point *A* on the

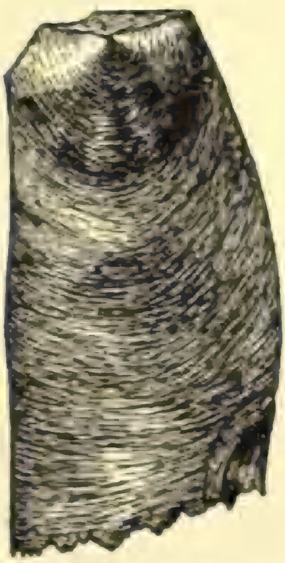

FIG. 19. Flake with salient bulb, struck off by a hard hammer. Brandon, Suffolk. Drawn by I. M. Allen.

FIG. 20. Flake with diffuse bulb struck by M. Coutier with a baton of boxwood. 1943.10.16. Drawn by I. M. Allen.

higher side of the platform and above the axis of the hammer. The platform at *A* is subjected to compression and the crack is started there before points on the lower side *B* come into contact with the hammer and are in turn subjected to compression which may or may not be sufficient to form a crack. The cone therefore is developed unsymmetrically, mainly on the "higher" side, and less or not at all on the lower side of the platform near to its front edge.'

2. On the other hand, in a flake produced by the blow of a soft hammer, a *diffuse bulb* is formed. This type of bulb is usually flat, there is no cone of percussion, and the platform-bulbar line has a distinctive lip running along it. Professor Barnes in his note on 1943.10.16 (Fig. 20) writes: 'The intersection of the bulbar surface of a diffuse-bulbed flake with its platform is formed by a continuous curve of oval shape with a slightly overhanging lip.' It should be noted that a slight lip is also present in some quartzite-struck flakes, so that the lip, although a feature

of the diffuse bulb, is not so safe a 'test' character between the hard-hammer and soft-hammer bulb as is the cone of percussion.

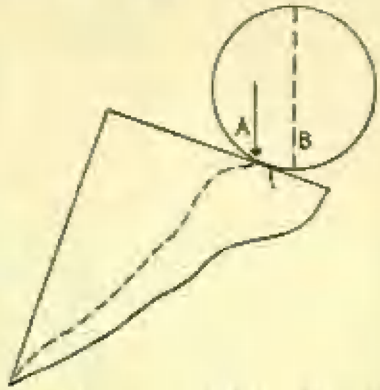

FIG. 21. Formation of a flake with a salient bulb, 1. 1943.10.11. Drawn by I. M. Allen from a model by Professor A. S. Barnes.

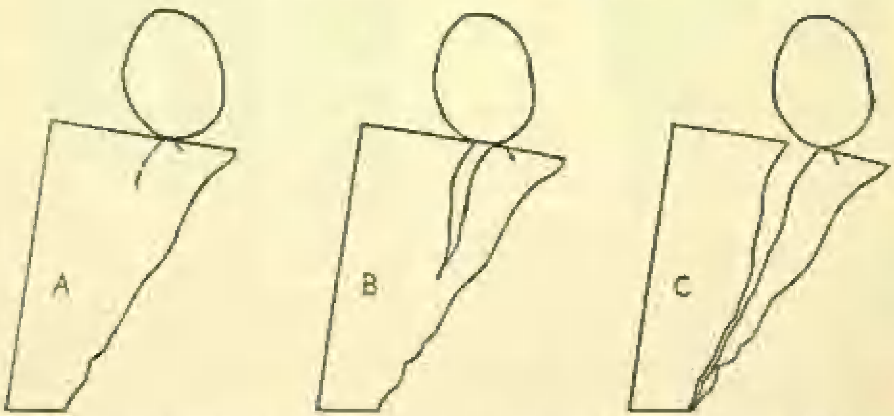

FIG. 22. Formation of a flake with a salient bulb, 2. The second important phase in the formation of a flake with a salient bulb is concerned with extension and completion of the crack formed at the point of impact. *A* shows the unsymmetrical cone formed by the blow. *B*. The friction between the hammer-stone and the butt of the flake and the continuation of the blow and its downward inclination extend the crack by 'tearing' action. *C*. The 'tearing' continues until the flake is completely severed from the core. Drawn by I. M. Allen from a model with the above note made by Professor A. S. Barnes for the Pitt Rivers Museum. 1943.10.12.

Variations in Hard-hammer Bulbs

Bulbs produced on flakes by the blows of hard hammers may be somewhat 'diffuse' in the following instances.

1. When the blow is struck on a ridge (*arrête*). Specimen made by Professor Barnes and presented by him to the Museum. In this example the bulb is fairly prominent, the cone of percussion is visible, and a slight

lip, perceptible to touch, runs along the platform-bulbar line as in a diffuse bulb.

2. When the blow is struck on a faceted platform. Specimen made and presented to the Museum by Professor Barnes. In this example the bulb is flat, there is a small cone of percussion, a contused platform, the platform-bulbar line is formed only on one-half of the platform, and along this there is a lip perceptible to touch.

3. To judge from the above examples, it seems likely that the bulb is not prominent when the blow is struck on a 'turned edge', i.e. a prepared-platform, in implement manufacture.

4. It seems likely that a blow struck on a cortex-covered surface will make a less prominent bulb, since the cortex will act as a 'cushion' to the blow, but there is no specimen available to prove this. Naturally the thickness of the cortex would affect the result.

5. Bulbs may also vary in saliency according to the technique of the worker, for they range from the Clacton-type flake with its large and often 'disengaged' cone of percussion to the neat bulbs of fine flaking work with a quartzite pebble.

With reference to variations in salient bulbs Professor A. S. Barnes has kindly allowed the following quotation from his as yet unpublished manuscript on the flakes and cores of the Acheulean period.

'*The Form of the Salient Bulb.* The form of the bulb is affected by the blow which forms its initial stage coupled with a number of other factors, viz., the tilting of the platform, the distance of the point of impact from the edge of the core, the manner in which the core is supported, e.g., in the hand, on an anvil, partly buried in sand or soft earth, the relative hardness of the hammer and the shape of the striking end, and the area of contact between the hammer and the core platform. The form and condition of the platform also affect the form of the bulb, e.g., the presence or absence of hard or soft cortex and its thickness; other factors are whether the surface of the platform is concave (dished), or with large or small facets. An important influence on the form of the bulb and the shape of the flake is due to the absence or presence and particularly to the arrangement of ridges on the flaking face of the core. These are designed to strengthen the flake against bending and breaking under the outward push of the blow or by vibration and by their spacing to limit the width of the bulb and flake. The dimensions and shape of the core also impose important limitations on the bulb. All the major phenomena of fracture can be reproduced by natural or artificial pressure as well as percussion.'

Variations in Soft-hammer (diffuse) Bulbs

The lip may run all along the platform-bulbar line, i.e. the line formed by the intersection of platform and bulb may be plainly visible, or so

slight as to be discernible to touch alone, or may be short, pronounced, and restricted more or less to the area that would in a hard-hammer bulb be marked by the cone of percussion. Variations also occur in the degrees of flatness of soft-hammer bulbs. It seems likely that these variations depend mainly upon the material of which the soft hammer is made (see detailed account on pp. 72 f.).

Form of Hammer

So far, then, this investigation has been concerned simply with the materials of which hammers may be made, and the effect of their blows as evidenced in the flakes struck off, and it is plain that from the appearance of a flake one can, to a certain extent, identify the material of which the hammer is made. But this is no guide to the *form* of the hammer itself. Can one tell whether the hammer is hafted, held in the hand, of knob form, or baton-shaped? It does not seem likely, certainly not with regard to quartzite pebble or iron hammer, for there would seem to be no difference in its blow whether it was delivered by a handled hammer, or by a pebble or iron lump held in the hand. Nor does it seem likely that the soft hammer in handled form, baton, or antler section held in the hand could be identified by the appearance of the flake. Nevertheless, before a definite opinion could be given, it would be interesting to see flakes struck off by a baton. Professor Barnes, in a letter to the writer, makes the following interesting observations on the question of baton form and bulb. 'A knob of boxwood would probably be used in a different way to a boxwood baton and would thus have a different area of contact, which is an important factor. Even if they were used in the same way, I think the areas of contact would be different owing to the shapes of the contact areas of the hammer.'

Other Diffuse-bulb Techniques

At this point it is necessary to refer to some diffuse-bulb techniques other than that of the soft hammer. They are:

1. Hammer-and-punch.
2. Pressure.
3. Impulsive-pressure (the technique of the Aztec Indians to produce fine obsidian flakes; see p. 85).
4. Impulsive-pressure-plus-percussion. This method is a combination of impulsive-pressure aided by percussion, and is described by

Catlin (see p. 85 of this book). It is to be presumed that it will also produce diffuse-bulbed flakes.

The first three techniques are represented by flakes in the Pitt Rivers Museum. Techniques 1 and 3 produce unmistakable diffuse-bulb flakes, as may be seen from the specimens in the collection.

But pressure flakes (technique no. 2) are only represented by nine flakes of milk glass which Professor Barnes removed by pressure with iron notched tools (cat. no. 1940.7.358), and in only one of these flakes is the platform well marked. In this specimen the bulb, &c., seem to conform to the usual diffuse-bulb type, though the lip is not discernible. It is possible that an iron pressure-tool might produce rather less 'diffuse' effects than would the softer antler, bone, or hard-wood tool. The scars of two half-inch-long pressure flakes on a flint implement made experimentally by the writer show shallow smooth flake-scars, and smooth shallow bulb-pits. They were produced by pressure with an antler tine. Compared to others produced, these two flakes were of exceptional length, but they probably gained their length by running along a single ridge. The evidence available therefore supports the conclusion that pressure produces diffuse-bulb flakes, and is a diffuse-bulb technique.

With regard to technique no. 4, since the technique of hammer-and-punch produces diffuse-bulb flakes, it would seem reasonable to suppose that impulsive-pressure-plus-percussion would produce similar flakes, as the two techniques are somewhat similar in their application to the core being flaked.

A Diffuse-bulb Investigation

There are, therefore, four techniques, the soft-hammer, hammer-and-punch, pressure, and impulsive-pressure, and probably a fifth, impulsive-pressure-plus-percussion, that will produce diffuse-bulbed flakes. Can one distinguish between the flakes they produce, and can one tell the material of which the soft hammer is made, so that the investigator can determine from the appearance of a diffuse-bulbed flake the method whereby the stone-worker detached it from the parent block? For that is really the main object of this inquiry, namely, *how far advanced in technique was the stone-worker who struck off the flake, what tools did he use, and what was his range of methods?*

For this inquiry the invaluable Technique Series made and collected by Professor A. S. Barnes and presented by him to the Pitt Rivers Museum is a storehouse of experimental fact and information. From

these specimens and the notes written by Professor Barnes to accompany them the following observations have been recorded.

1. Specimen no. 1943.10.15. Note by A. S. B. 'Actual indentations marking the areas of contact formed on a baton of soft wood by a series of blows delivered on flint. The contact areas when striking with batons of horn, bone, or antler are smaller in proportion to the hardness of the baton.'

2. *Diffuse bulbs produced by a wood baton.* Specimen no. 1943.10.16 (Fig. 20), a flake of light-grey chert. Note by A. S. B. 'Flake with diffuse bulb struck by M. Coutier with a baton of boxwood. The intersection of the bulbar surface of a diffuse-bulbed flake with its platform is formed by a continuous curve of oval shape with a slightly overhanging lip and is clearly shown in the above specimen.'

3. *Diffuse bulbs produced by an antler baton.* (*a*) Four flint flakes struck with antler by A. S. B. and presented to the Museum in 1935. *Flake no. 1*. Bulb fairly prominent, comparatively short lip; lip perceptible to touch, but might have been prominent had not some *éraillure* occurred here. *Flake no. 2*. Bulb fairly flat, lip perceptible to sight and touch, multiple fissures on platform. *Flake no. 3*. Struck with antler on a platform faceted with a brass hammer. Fairly flat bulb, short area of contact, very short and overhanging lip very plainly marked. *Flake no. 4*. Bulb fairly prominent, very small area of contact, small contused platform.

(*b*) Flint core and four flakes struck with an antler baton by A. S. B. One bulb is fairly pronounced, two are fairly flat, one is very incurved; some scaling or shattering of the edge of the core has taken place.

(*c*) Four glass flakes struck off with an antler baton by A. S. B. in making a hand-axe. Cat. no. 1940.7.59. Bulbs are on the whole rather salient, there is a very marked and overhanging lip on one flake, and some flakes have diffused bulbs, but are of irregular shape.

4. *Diffuse bulbs produced by an ivory hammer.* Professor Barnes kindly supplied the writer with the following information on the use of ivory as a hammer. 'With regard to soft hammers, I have used sperm whale tooth quite a lot as a hammer . . . as far as I recollect I found it perhaps rather harder than antler.' Professor Barnes also sent the writer three glass flakes struck by him with a sperm whale tooth. In two the platforms were defective, but the third is complete. In this there is a small but well-defined lip; there is no cone of percussion, and the bulb is of moderate prominence.

5. *Diffuse bulbs produced by hammer-and-punch.* (*a*) Cores and glass flakes struck by A. S. B. with hammer and boxwood punch (cat. no. 1940.7.352). On the whole the flakes show quite similar bulbs to those of the few Mexican obsidian flakes in the Museum. The Mexican flakes can almost certainly be ascribed to the pressure-by-impulsion technique. Some of A. S. B.'s punch-struck flakes show bulbs that may be described as pea-like in shape.

(*b*) Three glass flakes, the largest about 4 inches long, struck by M. Coutier with iron hammer and boxwood punch (given by A. S. B. to author). In these specimens there is some variation in bulb prominence, but the general character

of the bulb is flat, and the platform-bulbar line is a continuous curve of oval shape, but the lip is scarcely perceptible except to touch.

6. *Diffuse bulbs produced by impulsive-pressure.* There are four Mexican obsidian flakes, almost certainly produced by this technique, in the Pitt Rivers Museum. They all have cortex-covered platforms. Taken as a whole, they all show a slightly curved intersection of platform and bulbar face, i.e. a slightly curved platform-bulbar line, there is a slight lip, and a flat and somewhat pea-like bulb.

General Summary of the Results of the Foregoing Investigation into the Bulbs produced by the various Diffuse-bulb Techniques

1. It may be possible to tell the differences between flakes struck with a wooden baton and those produced by the blow of an antler baton, because the harder material, antler, is likely to produce more prominent bulbs on its flakes and to have a smaller area of contact on them. But with batons of intermediate degrees of hardness, as in bone, horn, &c., and the different degrees of hardness in wood, owing to their 'intermediate' effects in flake formation, it would not seem likely that identification of these materials would be possible from an examination of the flake-bulbs. Adding to the difficulties of identification is the variation in bulb forms among flakes produced by the same hammer, hard or soft.

2. Hammer-and-punch and impulsive-pressure appear to produce similar effects in bulb formation on the flakes they strike or push off, so that it would appear to be impossible to distinguish between these techniques from an examination of the flakes produced by them.

3. It seems possible that the pea-like shape of the bulbs that appear characteristic of flakes produced by hammer-and-punch and by impulsive-pressure would serve to distinguish their flakes from those struck off by batons. Also the ribbon-like shape of the flakes produced by the impulsive-pressure technique may be shared only by hammer-and-punch flakes. But more information is needed as to the possibilities in the production of long narrow flakes by baton, and it would also be necessary to know how far it is possible to produce them by an antler hammer.

The foregoing conclusions are based upon a comparatively small number of specimens. A more extensive investigation along these lines is needed in order to substantiate the results here tentatively summarized.

The Effect on Core and Implement of the Salient and Diffuse-bulb Techniques

1. When using a hard hammer, fine flaking on an *implement* is obtained by the use of a prepared-platform.

2. Flakes struck off a *core* by a hard hammer, and so with salient bulbs, may be coarse and heavy (cf. Clacton-type flakes), or they may be fine, long, and thin, as in some modern Stone Age work, and in the flaking with the iron hammer of the modern gun-flint worker. *Cores* struck by a hard hammer are characterized by deep bulb-pits, and have on the whole a coarser appearance than diffuse-bulb cores, i.e. those flaked by diffuse-bulb techniques. Nevertheless, the fact that finely flaked cores can be produced by the hard hammer is shown by the work of the modern gun-flint knapper.

3. In the finest work of the later Stone Age, *implements* were finished by long narrow flaking that we may presume was produced by hammer-and-punch, or pressure-by-impulsion. This gave them the fluted appearance characteristic of Danish flint daggers, American Indian knives, &c. In broader work, diffuse-bulb techniques *may* have produced the shallow and smooth effect seen in the broader flaking of some American Indian implements (cf. Chapter VI, p. 64).

4. *Cores* formed by diffuse-bulb techniques show a shallow and smooth flaking effect and narrow symmetrical flake-scars which give them a symmetrical and fluted appearance.

Division into two Classes of the Diffuse-bulb Flakes

1. *Those struck from an implement in implement manufacture.* These flakes may be long and narrow, i.e. ribbon-like, as in ripple-flaking, or they may be broad, as in clearing-flakes struck in blocking out, thinning, and shaping an implement. Flake-shape depends upon the 'quality' of the surface being flaked, i.e. whether it is smooth, or has previous flake-patterns running over it, and whether these patterns are narrow or widely spaced, or irregular, or symmetrical.

2. *Those struck or 'pushed' from a core for flake-production.* These flakes in general character are long, thin, and narrow. They may be very small as in Mesolithic-type cores, or long and ribbon-like, as in Aztec obsidian cores, or of impressive size as in those 'struck' from Pressigny cores. See also Catlin's account of 10–12-inch flakes produced by a method of pressure-by-impulsion-plus-percussion on pp. 85–87 of this paper.

Practical Applications of Diffuse-bulb Techniques

Soft hammers give shallow smooth flaking, not so much material is taken off the piece being worked, and it is possible that the material may be less jarred than when worked with a hard hammer. Nor is a prepared-

platform essential in wooden baton work, though Professor Barnes in his experimental work found that the occasional preparation of a platform was of considerable practical use during the manufacture of a hand-axe with antler and horn batons and hammers. Thus it may be that the two techniques are interchangeable in this respect. But from a developmental point of view the use of soft hammers would not necessitate the evolution of the prepared-platform.

With regard to hammer-and-punch and pressure-by-impulsion, great accuracy combined with fine flaking is gained by the use of these techniques. In *core-flaking* by these methods, some chipping of the platform in order to seat the flaking-tool was often employed by the stone-worker (Barnes, 1947, and Catlin quoted by Sellers, 1885, pp. 874–5). In *pressure-work in implement manufacture*, where long narrow flakes were to be pressed off, a prepared flaking-platform is a necessity (Elkin, *Man*, 1948, no. 130).

Diffuse and Salient Bulbs in Palaeolithic Flakes

The question now arises as to when the diffuse-bulb techniques were first developed by the stone-worker, and the surest proof of their occurrence would be the presence of diffuse-bulb flakes among his implements. The following information has been collected by the writer.

English Lower Palaeolithic period. An analysis has been made of the platforms and bulbs of a large series of flakes collected from the gravels at Biddenham in Bedfordshire by the writer for the Pitt Rivers Museum during the years from about 1900 to 1911, in order to discover what type of hammer had been used by the flint-workers in the technical period covered by the flakes in these gravels. The collection comprised a large number of hand-axes, many flakes and flake-implements, and a few cores. Some of the cores are of Clacton-type, others represent stages in the development from Clacton-type to 'tortoise'-type cores, and two or three are characteristic 'tortoise'- and disk- cores. Only two flakes were found that seemed to have been struck from 'tortoise'-type cores, but it may be that some of the flakes classed as 'those with irregular platforms' were struck from 'tortoise'-and disk-type cores. Any flake with characteristic faceted-butt would not have been overlooked. There were indeed a few in which the butts had been faceted *after* they had been struck from the core, presumably to make them into scrapers.

Since the study of Professor Barnes's experimental specimens (p. 68)

has shown that there was a considerable variation in hard-hammer bulbs, and that the type of platform influenced the form of the bulb, it seems satisfactory to divide the flakes in the Biddenham collection into five categories based on the type of platform:

1. Flakes with flat or flattened platforms.
2. Flakes with irregular platforms.
3. Flakes with platforms covered with cortex, and therefore struck from the outside of a nodule or block.
4. Flakes with faceted butts, struck from 'tortoise'- and disk-type cores.
5. Flakes with butts that have been faceted *after* being struck from the core.

Observations were recorded:

1. On the place where the blow fell on the flake-platform, i.e. as to whether there was a well-marked unsymmetrical cone of percussion characteristic of the blow of a hard hammer (see p. 66), or whether there was a flat bulb and a lip characteristic of the blow of a soft hammer (see p. 67).
2. As to the saliency or flatness of the bulb.
3. On presence or absence of a lip.

With regard to no. 1, it was soon found that although there were many cases in which the unsymmetrical cone was well marked, there were others in which it was difficult to distinguish, or in which the cone was atypical, although from the general appearance it was reasonably certain that the blow had been given with a hard hammer. In a few, again, the mark where the blow fell on the flake was so atypical or difficult to decipher that the type of hammer must be considered as doubtful. Therefore in each of the five categories the flakes therein have been divided into five classes.

(*a*) Flakes characterized by a well-marked unsymmetrical cone of percussion. These flakes have therefore been struck off the core by a blow of a hard hammer, presumably a quartzite hammer-stone. This class is labelled *H*.

(*b*) Flakes characterized by the atypical appearance of the cone, but the blow of a hard hammer is either certain or probable. This class is labelled *P-H*.

(*c*) Flakes characterized by an atypical appearance of the cone, and generally difficult to diagnose, so that they have been placed in a class

in which the type of hammer may be considered doubtful. This class is labelled *D*.

(*d*) Flakes characterized by a semi-diffuse type of bulb. The type of hammer must therefore be considered doubtful, though some 'softness' of hammer may be indicated. Flake no. 256 would appear to indicate that an inclusion in the flint may cause a semi-diffuse effect (see note on p. 78). This class is labelled *S-Diff*.

(*e*) Flakes characterized by diffuse bulbs. The blow of a soft hammer is therefore probable. This class is labelled *Diff*.

With regard to the characters of the *bulb*, it was found that even though the unsymmetrical cone showed the effect of the blow of the hard hammer, yet bulbs varied from salient to flat. Observations on this feature have therefore been divided as follows: *salient*, *semi-salient*, *flat or flattened*, *semi-diffuse*, *diffuse*.

Observations on the presence or absence of the *lip* usually characteristic of a soft-hammer bulb have been divided into three groups: *marked*, *slightly marked*, *no lip*.

Observations of this nature cannot have sufficient precision to be of much scientific value. Nevertheless, the divisions may serve to give some idea as to the variations in the form of platform, cone, bulb, and lip.

A certain number of flakes was omitted because of defects in the platform or bulb owing to accident, large *éraillure*, &c., but 282 flakes out of the Biddenham collection could be used for analysis. The results of the investigation into the characters of these flakes along the foregoing lines are summarized in the following tables.

282 PALAEOLITHIC FLAKES FROM THE BIDDENHAM GRAVELS

Category 1. Observations on 155 Flakes with Flat or Flattened Platforms

		Bulb					*Lip*		
Classes of flakes	*No.*	*Salient*	*Semi-salient*	*Flat or flattened*	*Semi-diffuse*	*Diffuse*	*Marked*	*Slightly marked*	*No lip*
H	128	117	4	7	—	—	—	1	127
P-H	19	10	5	4	—	—	—	4	15
D	1	—	—	1	—	—	—	—	1
S-Diff.	5	1	2	2	—	—	2	1	2
Diff.	2	—	—	—	—	2	2	—	—
Total	155	128	11	14	—	2	4	6	145

Category 2. Observations on 74 Flakes with Irregular Platforms

	Bulb						Lip		
Classes of flakes	*No.*	*Salient*	*Semi-salient*	*Flat or flattened*	*Semi-diffuse*	*Diffuse*	*Marked*	*Slightly marked*	*No lip*
H	43	34	5	4	—	—	—	—	43
P-H	27	15	10	2	—	—	—	1	26
D	2	1	1	—	—	—	—	1	1
S-Diff.	2*	—	1	1	—	—	—	1	1
Diff.	—	—	—	—	—	—	—	—	—
Total	74	50	17	7	—	—	—	3	71

* In one of these flakes, no. 256, the semi-diffuse bulb is almost certainly due to the fact that the platform consists of a stony inclusion, and it seems probable that it was struck with a hard hammer. It has a flat bulb and no lip.

Category 3. Observations on 46 Flakes with Cortex-covered Platforms

	Bulb					Lip		
Classes of flakes	*No.*	*Salient*	*Semi-salient*	*Flat or flattened*	**Semi-diffuse*	*Marked*	*Slightly marked*	*No lip*
H	24	10	7	7	—	—	—	24
P-H	12	7	2	3	—	—	1	11
D	6	—	2	3	1	—	1	5
S-Diff.	4	—	—	—	4	—	—	4
Total	46	17	11	13	5	—	2	44

* No diffuse bulbs.

Category 4. Observations on 2 Flakes struck from a 'Tortoise'-type Core

One flake with faceted-platform, probably struck from a 'tortoise'-type core, but some of the faceting may have been done after the flake was struck off. *Class H, salient bulb, no lip.*

One flake with cortex-covered platform. *Class H, salient bulb, no lip.*

Category 5. Observations on 5 Flakes with Platforms faceted after being struck from a Core

Four in class H, salient bulbs, no lips.
One in class P-H, salient bulb, no lip.

Summary of Analysis

Out of a total of 282 flakes, 260 have either certainly, or most probably, been struck off by a hard hammer.

There is some considerable variation in the hard-hammer bulb. The form of the bulb is likely to be influenced by the shape of the platform and by the presence of cortex (cf. experimental specimens of Professor Barnes, p. 68). The presence of stony inclusions in the platform seems to be liable to cause a semi-diffuse effect (cf. note on flake 256 on p. 78). Variations in the quality of the flint, and variations in the hardness of the hammer-stone might also have their effect on the form of the bulb.

There are only two diffuse-bulbed flakes. These are likely to have been struck with a soft hammer, but they are so few in number that it seems reasonable to regard them as accidental and not due to a purposeful soft-hammer technique.

Of the remaining twenty, nine are classified as doubtful, and eleven as semi-diffuse. The type of hammer used for these may therefore be queried, but the type of bulbs exhibited by these flakes *may* be due to aberrant hard-hammer effects, i.e. to some of the possible influences noted above.

Occurrence of Diffuse and Salient Bulbs in Flakes of the French Middle and Upper Palaeolithic Periods

For the *Middle Palaeolithic*, M. François Bordes (1947, p. 25) gives percentages for the Moustierian of Pech-de-l'Aze, Dordogne.

Principal Layer. Faceted-butt flakes struck by stone or wood, 36 per cent.; smooth platforms, stone-struck, 30·2 per cent.; smooth platforms, struck by wood, 33·6 per cent.

Upper Layer. The respective frequencies of the above classes were 36·7 per cent., 25·6 per cent., and 37·5 per cent.

For the *Upper Palaeolithic*, Professor A. S. Barnes and Mr. H. H. Kidder (1936, p. 5) record the following occurrences of salient and diffuse bulbs.

		Salient bulbs per cent.	*Diffuse bulbs per cent.*
Moustierian	Lower	90	10
	Middle	95	5
	Upper	83	17
Perigordian I		93	7
Aurignacian	Pointes à base fendue	48	52
	Pointes aplaties	38	62
	Pointes ovales	73	27
	Pointes biconiques	68	32
Perigordian V		32	68

M. Bordes's percentages for the Moustierian of Pech-de-l'Aze and Professor Barnes's and Mr. Kidder's for La Ferrassie form a valuable contribution from the French Middle and Upper Palaeolithic. The Biddenham series is a satisfactory one in point of numbers, but it represents of course only one small area in England. Similar work from other areas is needed.

Chapter VIII

THE TOOLS USED IN FLAKING-WORK BY MODERN STONE AGE PEOPLES

THE hammer-stone is a lasting object, and may be looked for and probably found on flaking sites of any date. But the diffuse-bulb tools made of softer materials disintegrate with time, or become so weathered, for example, bone and antler, that their use and purpose may be unrecognizable. Only from the bulb-shapes of the flakes they have struck off, or from the appearance of the flake-scars on the implements they have made, can the nature and material of the diffuse-bulb flaking-tools be conjectured.

Fortunately within modern times there have been native stone-flaking peoples still making and using implements of flakes and flaked-stone, and there have also been European observers interested enough to make records of the methods employed. It may therefore be useful to set forth here some extracts from the published descriptions of flaking techniques in two areas in which this work has been carried out in recent times, i.e. America and Australia, because the tools and techniques in these countries are likely to represent those employed in other periods and places.

America

The flaking-work of the American Indian stone-worker is equal[1] to that of the prehistoric Late Stone Age flaker in Europe and the Middle East, and it is reasonable to suppose that his methods were similar since many of the results achieved are alike. At the time of the arrival of the European the Indians were at the summit of the Stone Age with regard to technique. Some areas were already in the Metal Age. So far as stone-working was concerned, they could ripple-flake their implements, make amazing flaked-points of chert[2] and obsidian,[3] and by means of an in-

[1] Perhaps the Predynastic Egyptian ripple-flaked chert knives should be excepted, for they are in a class by themselves. The Danish fluted and handled flint knives are also peerless. But some American Indian work is very remarkable. Moorehead (1911, vol. i, p. 245) states '... prehistoric man in America was at least the equal, and possibly the superior of Neolithic man in Europe', and his illustrations prove his point, e.g. the large obsidian and chert flaked implements.

[2] Moorehead, 1911, p. 164 and Fig. 161, stone swords from Tennessee; the longest one figured is 20 in. For discussion of these chert swords see pp. 244–6. See also Shetrone, 1930, p. 439 and Fig. 281, for two extremely long and fine ceremonial knives or swords chipped from flint, found by Moorehead, from the Etowah Group.

[3] Shetrone, 1930, p. 76. 'The impressive ceremonial blades from the Hopewell Mounds, some of

genious instrument push off ribbon-like flakes from obsidian cores.[1] The manufacture of their large implements and their ripple-flaking of them have not been recorded, but their arrow-head manufacture has interested white men who came into contact with them while they were still making stone weapons, and there are a number of accounts of this on record, while some of their other stone-working processes have also been seen and recorded.

Australia

In Australia also, the flaking-work of the aborigines is very fine and worthy of study. In the Kimberley District at the present day the tribesmen still make beautiful spear-heads of flaked stone and glass. Though these are not usually of great size, for skill and artistry in workmanship they are unsurpassed, and the processes by which they are made have been recorded by a number of European observers.[2] The stone-working methods of the Australian aboriginal in general have also been studied by scientific investigators (Roth, 1904, Spencer and Gillen, 1904, Spencer, 1914, Basedow, 1925).

Thus in these two areas of the world, America and Australia, stone-working was until recent times a thing not of the past but of the present, and the stone-worker was using methods probably similar to those of peoples far distant in place and time. The following literary references describe the tools and techniques used by native stone-workers in North America and Australia.

TOOLS USED BY THE STONE-WORKERS OF NORTH AMERICA, AND THE MATERIALS OF WHICH THEY ARE MADE

Aleuts

Jochelson, 1925, p. 67. 'The following data are based not only on the implements themselves, but on statements of old Aleut, particularly those on Umnak Island, who seemed to know more about the primitive techniques of their forefathers than any of the other islanders. Some stone implements, such as fish-hook sinkers and stone blades for throwing-lances used in hunting were still in use. Because of this it was possible to establish the use of all the objects of the lithic industry of the old Aleut.'

Hammer-stones, p. 68. 'The short hammer-stone . . . was held in the right hand;

which measure 18 in. in length, and more than 6 in. in width, must have been the cherished possessions of the chiefs or priests, possibly used and displayed only on the occasions of important ceremonies.' See also p. 148, Fig. 87, a ceremonial blade of obsidian, over 17 in. long, and one of quartz, 13 in. long.

[1] Evans, 1897, pp. 23–24, on accounts of Torquemada in 1615, and of Hernandez in 1651. See also Tylor, 1861, appendix on obsidian knives, pp. 331–2.

[2] Elkin, 1948, quoted on p. 89.

in working with this implement, skill in handling it was more important than a powerful stroke.' P. 69: 'The final shape to a stone implement was given it by trimming or retouching after the form had been thinned out with the . . . hammer-stone.'

Pressure-flakers, p. 70. 'The bone-flaker . . . was usually made of the penis bone of a sea-otter (see plate 22, figs. 16, 17). It is a very dense and hard bone substance, but, in distinction from stone, possesses a certain degree of elasticity.' P. 71: 'They [pressure-flakers] were also made of the outer layer of a walrus-tooth and of the incisors of the killer whale.' Three pressure-flakers are shown in Fig. 41, p. 70. Fig. 41A is of walrus tusk, and Fig. 43 a model of a flaker made of a killer whale's tooth fitted to a wooden handle representing a sea-lion, and made by an old Aleut of Umnak Island.

Eskimo

Pressure-flakers of caribou antler mounted in handles of fossil ivory and of wood, used by the Eskimo, are illustrated by Sir John Evans (1897, p. 38). See also the Eskimo arrow-flakers in the Pitt Rivers Museum.

Holmes (1919, p. 319, quoting Nelson, 1899) says 'the flakers are made of small rodlike pieces of deer-horn, wood, or ivory, fastened into a slot at the end of a handle, usually of ivory or deer-horn, with wrappings of sinew or rawhide cord'. P. 319, Fig. 181 (quoting Murdoch, 1892, pp. 287–8): illustration and description of bone chipping implement of the Eskimo. P. 320: 'It would appear that the highly specialized curved flaker-handle used by the Eskimo (fig. 181) was in use as far south as California.' (Followed by quotation from Mason on the Ray collection from the Hupa Reservation, Mason, 1889, pp. 228–9, on this matter.)

Evans, 1897, p. 37. 'Sir Edward Belcher (1861, London, p. 139, and Paris, p. 341), who had seen obsidian arrow-heads made by the Indians of California, and those of chert or flint by the Eskimo of Cape Lisburne, states that the mode pursued in each case was exactly similar.' Evans, p. 39. 'Sir Edward Belcher some years ago kindly explained the process to me, and showed me both the implements used, and the objects manufactured. It appears that the flake from which the arrow-head is to be made is sometimes fixed by means of a cord in a split piece of wood so as to hold it firmly, and that all the large surface flaking is produced either by blows direct from the hammer, or through an intermediate punch or set formed of reindeer horn. The arrow- or harpoon-head thus roughly chipped out is afterwards finished by means of the "arrow-flaker".'

Holmes, 1919, p. 321, quotes Sir Edward Belcher (from Wilson, T., 1899, p. 986) for the use of a deer-horn point lashed to a handle of fine fossil ivory as a pressure-flaker by the Eskimo of Icy Cape.

American Indian Tribes, General

Hammer-stones. For the use of hammer-stones among the American Indian tribes, see Holmes, 1919, chapter XXIX and Figures, also pp. 178 and 180. Holmes, p. 325. 'With obsidian the hammer makes the flake and thins down the

thick edges, and the bone point shapes the arrowhead with ease; with the tougher materials, especially when the objects are large, the range of the stone hammer's work is much greater, and, indeed, the bone point by free-hand methods is often available only in the refinements of finish and in many cases not at all.' P. 318 (quoting Morice, 1895, p. 65): 'The first operation consisted in roughly blocking off with a hard stone the pieces of the flint, the removal of which was necessary to obtain a vague resemblance to the intended weapon.'

Antler Hammers. There is no modern mention of their use. But they were found at a quarry in south Illinois where large chipped blades were made by the Indian stone-workers. Holmes, p. 193 and Fig. 74, describes and illustrates these hammers, chipping implements made of the base of deer antlers, 'probably used rather in the secondary trimming of the blades than in the roughing-out work'. P. 284: 'Hammers made of a section of the indurated base of deer and elk antlers were in common use in some localities for the lighter chipping work.'

Evans, 1897, p. 41. 'Beyond the pin of bone already mentioned as having been found in one of the pits at Grimes Graves, I am not aware of any bone or horn implements of precisely this character, having been as yet discovered in Europe, but hammers of stag's horn and detached tines have frequently been found in connexion with worked flints, and may have served in their manufacture.'[1]

The advantages of a hammer-stone to the worker are concentrated weight, hardness, and toughness. These qualities enable the worker to break up or 'quarter' blocks of siliceous stone, flake pieces or nodules of it into shape, or strike from the cores or 'quarters' both large and small flakes that can be manufactured into spear-head, arrow-head, or knife. The hammer-stone is capable of great accuracy in skilled hands.

The advantages of an antler hammer to the worker are the smooth and shallow flaking it gives, as may be seen in the flaking-finish of Illinois and Missouri hoe-blades.

Hammer and Punch. Catlin (1868) describes the use of a mallet of very hard wood and a punch made from a sperm-whale tooth in the manufacture of arrowheads by the Apache Indians. In Chapter V, p. 188, he says: 'The master workman, seated on the ground . . . places his chisel (or punch) on the point to be broken off, and a co-operator (a striker) sitting in front of him with a mallet of very hard wood, strikes the chisel (or punch) on the upper end.' P. 189: 'These people have no metallic instruments to work with, and the instrument (punch) which they use I was told was a piece of bone, but on examining it, I found it to be a substance much harder, made of the tooth of the sperm whale or sea-lion, which are often stranded on the coast of the Pacific. This punch is about six or seven inches in length and one inch in diameter, with one rounded side and two

[1] Dr. Joan Evans describes her father Sir John Evans as 'breaking the white nodule of flint into quarters with a rounded pebble, and striking at the lesser block with his hammer of reindeer horn' (Joan Evans, 1943, p. 134).

plane sides, therefore presenting one acute and two obtuse angles, to suit the points to be broken.' (This passage is quoted by Holmes, p. 295, Stevens, p. 82, and T. Wilson, p. 985.)

Holmes, 1919, p. 296, quotes Redding, 1879, for the use of a punch of split deer-horn with a hammer-stone by the Wintoons of Cloud River, Oregon, and Evans also quotes Redding, 1880, and Redding in *Nature*, vol. xxi, p. 613, to the same effect. Holmes, p. 302, refers to punches made of stone, hard bone, or antler, and a mallet or hammer. On p. 326, describing the flaking-work of Ishi, a Yahi Indian of southern California, Holmes refers to the use of a hammer-stone, and a hammer-stone and wood or bone punch in the preliminary rough work in making a large blade. Pull, 1932, p. 114, writes: 'No definite bone punches have been found, but I have experimented with tines of red deer antler, and have no doubt that many of the smaller antler tines recovered from the shafts and workshop floors may have been used in this way.'

The advantages of hammer-and-punch to the worker are accuracy plus strength of blow plus shallow flaking, also steeper flaking than could be carried out with the hammer-stone. The large fluted chert cores and small fluted jasper cores from India in the Museum seem likely to have been the work of hammer-and-punch. There is also the right-angle flaking, probably done by hammer-and-punch, on the sides of Danish flint axes.

Impulsive-pressure with a crutch-shaped flaking tool. For a translation of the accounts by Torquemada in 1615 and by Hernandez in 1651 of the crutch-shaped wooden implement used in flaking obsidian by the Aztecs of Mexico, see Tylor, 1861, pp. 331–2. These accounts are also quoted by Evans, 1897, pp. 23–24, and by Holmes, 1919, on pp. 323–4. On p. 322 Holmes quotes Sellers's (1885, p. 870) record of Catlin's account of flint-working processes among the tribes of the Middle and Far West, and illustrates in Fig. 182, p. 323 (Holmes) a Mexican Indian flaking as described by Torquemada, and flaking by western United States tribes as described by Catlin. T. Wilson (1899, p. 988) also gives Torquemada's account. Catlin, quoted by Sellers (1885, p. 870), called the process 'impulsive-pressure'. The flaking-shafts 'were pointed with bone or buck-horn, inserted in the working-end as represented in Fig. 1' (Fig. 23, p. 86).

To summarize the technique, the worker placed the pointed end of the flaking-staff on the core, and then threw his chest forward on to the crutch-shaped end, thus applying a forceful pressure-blow to the core.

Impulsive-pressure-plus-percussion with the crutch-shaped flaking tool. Sellers (1885, p. 875) writes: 'Fig. 2 [Fig. 24, p. 86] represents, as nearly as I recollect, the rude sketches made of the flaking-tool used to throw off massive flakes, when a sudden percussive pressure was required in addition to the impulsive pressure the man could give. . . . The tooth or tusk of the walrus was highly prized for

FIG. 23. Wooden flaking-staff for impulsive pressure, 30 in. to 4 ft. long, 2–3 in. diameter, pointed with bone, buck-horn, walrus-tusk, &c. Drawn by I. M. Allen from the sketch and description by G. E. Sellers, *Ann. Rep. Board of Regents, Smithsonian Inst.*, *1885*, p. 874.

FIG. 24. Wooden flaking-staff pointed with walrus-tusk, for impulsive-pressure-plus-percussion. The branch on the left side was used to secure a heavy stone. The cross-piece is against the operator's chest, and when he throws his weight on it, an assistant gives a sharp blow in the crotch on the right-hand side with a wooden club of oval section shown on the right of the staff. Drawn by I. M. Allen from the sketch and description by G. E. Sellers, *Ann. Rep. Board of Regents, Smithsonian Inst.*, *1885*, p. 875.

tips of the flakers. . . . It has been represented to me that a single blow rarely failed to throw off the flake, frequently the entire depth of the block of stone, sometimes as much as 10 or 12 inches.'

To summarize the technique, at the instant the operator threw his weight on to the flaking-staff an assistant also struck a projection on the flaking-staff with a wooden club, thus adding percussion to the impulsive-pressure.

The advantage of the crutch-shaped tool in the impulsive-pressure technique is accuracy, plus half-blow half-pressure force, which enabled the worker to produce long, thin, narrow, and symmetrical flakes. A further advantage is that cores could be flaked to a right angle and even beyond, as may be seen in a large Mexican obsidian core in the Pitt Rivers Museum. In the impulsive-pressure-plus-percussion technique, it was probably more effective when long and large flakes were required, and when chert was being worked.

Pressure-flakers of bone. Evans (1897, p. 40) writes: 'Captain John Smith [1812, vol. xiii, pp. 35–36] writing in 1606 of the Indians of Virginia, says 'His arrow-head he maketh quickly with a little bone, which he ever weareth at his bracert' (i.e. bracer, girdle, or bandage). This is also quoted by Stevens, 1870, p. 79, and by Holmes, 1919, p. 316, from Smith, 1629, vol. i, p. 132.

Moorehead (1911, p. 49, Fig. 41) illustrates 'Mandan bone chipping-tools. These were made use of in flaking flint implements, Mandan village-site, North Dakota. . . .' Holmes, p. 312, writes that among the California Indians, probably one of the Shoshonean tribes, Lieut. E. G. Beckwith (1855, p. 43) records a pressure-flaker of a 'simple piece of round bone'. Again, Holmes (p. 316) refers to Sellers (1885, pp. 872–3) who records the use of a small pointed bone for pressure-work by American Indian women chipping flakes into small arrow-points, as described to him by Titian R. Peale, who accompanied Lewis and Clarke on their exploration to the Pacific. Holmes (p. 318, quoting Dulog, as quoted by Mason, 1894, p. 658) describes pressure-tools of bone ground down to a blunt point. 'These tools [were] made often from the leg-bone of a deer.'

Pressure-flakers of antler tine. G. E. Sellers (1885, p. 877) writes with reference to a work-site on the northern bank of the Saline River about three miles above its junction with the Ohio, 'the great flood of the winter of 1862 and 1863 that overflowed this ridge some three or four feet . . . exposing over six acres of what at first appeared to be a mass of chips or stone rubbish, but amongst it were found many hammerstones, celts, grooved axes, cores, flakes, . . . many tines of the buck or stag, all of which bore evidence of having been scraped to a point; on exposure to the air they fell to pieces.' (This passage is also quoted by Sir Daniel Wilson, 1889.)

Holmes (1919, p. 314) quotes Redding (1879) on arrow-making among the Wintoons of Cloud River, Oregon. 'The demonstration was made by an old

man named Consolulu who "brought, tied up in a deer-skin, a piece of obsidian weighing about a pound, a fragment of a deer-horn split from a prong lengthwise, about four inches in length and half an inch in diameter, and ground off squarely at the ends—this left each end a semicircle—besides two deer prongs (*Cariacus columbianus*) with the points ground down into the shape of a square, sharp-pointed file, one of these being much smaller than the other".' A hammerstone and a piece of deer-horn were then used as a hammer and punch (see p. 84). The pressure-work was performed by 'the larger of the two deer prongs, which had its pointed end sharpened in the form of a square file'. Pp. 315–16. In making the notches he 'used the smaller deer prong which had been sharpened in the same form as the larger one, but all its proportions, in every respect, were very much smaller; its point could not have been larger than one-sixteenth of an inch square'. Holmes (p. 310) also describes a deer-horn tool for pressure-work recorded by Powell (1895, pp. 1–2) as used by the Shoshoni arrow-makers 'in a little valley north of the Uinta Mountains' in 1869, 'a deer-horn tool from eight to twelve inches in length and worked down from its original size by grinding so that its diameter was about five-eighths of an inch'. On p. 316 Holmes describes chipping implements 'made of buckhorn reinforced with a piece of "rabbit brush" ', used by an aged Washoe Indian. These are illustrated in Holmes's Fig. 173*b*.

Antler and Tooth. Holmes, p. 312, quotes Schumacher (1877, p. 547) who records a pressure tool of a stick about 1½ feet in length with a point of the 'tooth of a sea lion or the horn of elk' used by the Klamath Indians of California.

Stone and Tooth. Holmes, p. 318, quotes Father Morice (1895, p. 65) who describes an elongated stone pressure-flaker in use among the Déné arrowmakers, also the use of a moose molar tooth to replace in not a few cases the long chipping stone.

For illustrations of pressure chipping tools see Holmes, p. 307, Fig. 173.

Other methods akin to pressure-work. Sir John Evans (1897, p. 39) quotes Gastaldi as translated by Chambers (Gastaldi, 1865, p. 106) on arrow-making among the Indians of Mexico. Chambers says of Signor Craveri: 'He relates that when the Indians wish to make an arrow-head or other instrument of a piece of obsidian, they take the piece in the left hand, and hold grasped in the other a small goat's horn; they set the piece of stone upon the horn, and dexterously pressing it against the point of it, while they give the horn a gentle movement from right to left, and up and down, they disengage from it frequent chips, and in this way obtain the desired form.'

Sir John Evans follows this account by one of other methods on the same page. 'M. F. de Pourtales (Mortillet, vol. ii, p. 517) speaks of a small notch in the end of the bone into which the edge of the flake is inserted, and a chip broken off it by a sideways blow. Mr. T. R. Peale (Stevens, 1870, p. 78) describes the manufacture of arrow-heads among the Shasta and North Californian Indians, as being effected by means of a notched horn, as a glazier chips glass. This has also been fully described and illustrated by Mr. Paul Schumacher (1874, p. 263, and 1877, p. 547) of San Francisco. Major Powell confirms this account.'

W. H. Holmes (1919, p. 324) also discusses this method. See especially the account of Mexicans using a small goat's horn.

Advantages of pressure-flaking to the worker. It is a handy and effective method of sharpening, pointing, serrating, and shallow-notching a stone implement. For a discussion as to method see Knowles, F. H. S., 1944. For its possibilities in the manufacture of a spear-head in the skilled hands of an aboriginal, see Elkin, 1948. A summary appears below.

Stone-working Tools used by the North-western Australian Aborigines in the Manufacture of their Flaked Spear-heads

Professor A. P. Elkin (1938, p. 64) shows a photograph of a man making a spear-point by pressure-flaking, and on p. 17 he writes: 'the Ungarinyin and Worora in the Northern Kimberley . . . are experts in making stone spear-points by pressure flaking, a highly technical process only practised in its true form in Northern and Eastern Kimberley. Such a spear-point is itself a work of art.'

Professor Elkin's paper on pressure-flaking in the northern Kimberley (1948) shows a plate of six photographs illustrating the technique, and the article contains a clear and detailed account of the processes involved in the manufacture of a spear-head, and should be carefully studied, for it is a masterly and complete piece of work. The tools used by the native worker are a hammer-stone, hard wood and bone pressure-flakers (a piece of stout fencing wire may also be used), a table stone, and a grindstone. The side of the table stone may be used as the grindstone. For the description of the processes, the whole paper should be read, but the following may be quoted here for its interest in connexion with the present work. P. 112: 'The whole process takes hours of constant and concentrated effort, with much skill and patience. It includes the preliminary knapping of the core, which is followed by the chipping or knocking-off of flakes to reduce the core to the approximate size and shape required, with a semblance of edges. The third stage consists of pressure flaking, mainly with the thicker and softer-pointed instrument, while in the fourth stage only a very sharp-pointed instrument is used. But the process in both the second and third stages includes the preparation of the striking and pressure platforms respectively by "turning the edge". . . . Finally, the observer cannot help noticing the skill shown by the craftsman, his sureness of touch, his command of his instrument and of the material he is working. . . . The craftsman is aware that a bad stroke will ruin hours of work, but he knows where and how hard to hit or press. . . . I saw sureness and continuous awareness of the goal—the formation by percussion and pressure of a useful and beautiful object.'

Basedow (1925, p. 368 and Plate LIV) gives a detailed account, with plate, of the manufacture of finely flaked spear-heads by the north-western tribes. The flake is chipped into shape with a hammer-stone, and finished by pressure-flaking with a bone tool.

Love (1936, p. 72) shows a Worora man making a spear-head by the second process, pressure-flaking with a blunt wooden tool. P. 74 shows finely worked stone spear-heads made by the Worora, and p. 75 shows the tools used by the Worora in making the stone spear-heads, first, the hammer-stone for the first stage, secondly the wooden pressure-flaker for the next stage of the work, and thirdly the kangaroo-bone tool for making the fine serrations in the edges of the spear-head. On p. 74 he says: 'These stone spear-heads . . . are made by percussion, then flaking by pressure, with stone, bone and wood tools, from several kinds of fissile stone.'

Chapter IX

THE FLINT-WORKER HIMSELF

It seems likely that in all stone-working times every member of the tribe could make his or her[1] own stone tools, but that in later days, with increase in specialization, implement manufacture, at any rate as regards the finer products, became a skilled occupation. Some literary references from America and Australia are of interest in this matter, for they are observations by Europeans who were in contact with native stone-workers while they were still making their stone implements in the traditional manner.

Social organization in America ranged from nomadic hunting tribes, using stone, bone, &c., to city dwellers of advanced culture, who were skilled architects and metal-workers, but still used stone for various implements. The references in the literature suggest that among the tribes stone-working was, on the whole, a specialized occupation or profession, and that among the workers there were master-flakers pre-eminent in experience and skill.

In Australia, society consisted of small scattered hunting tribes, and the flaking of fine spear-heads appears to have been a tribal rather than an individual accomplishment. But even in the tribe that specialized in spear-head manufacture there would appear to have been individuals rather more gifted in flaking skill than their fellow workers.

The Stone-worker in America

Catlin (1868, pp. 187–90) writes an account of arrow-head manufacture by the Apache Indians. This journey was made about 1853, and there is an account of it in his Preface to *Life among the Indians* (1874). 1868, p. 187: 'Like most of the tribes west of and in the Rocky Mountains they manufacture the blades of their spears and points for their arrows of flints and also of obsidian, which is scattered over these volcanic regions west of the mountains, and, like other tribes, they guard as a profound secret the mode by which the flints and obsidian are broken into the shapes they require.' P. 188: 'Every tribe has its *factory* in which these arrow-heads are made, and in those, only certain adepts are able or allowed to make them for the use of the tribe.' (Quoted by Stevens, 1870, p. 82).

[1] Campbell and Noone (1943, p. 299) refer to 'Tasmanian women making 'nosed' scrapers (*grattoirs à museau*), and Sellers (1885, pp. 872–3) and Holmes (1919, p. 316) record the use of a small pointed bone for pressure-work by American Indian women chipping flakes into small arrow-heads.

Schoolcraft (1853, part iii, p. 467) writes on the manufacture of flint arrow- and spear-heads by the Indians. 'Such is the art required in this business, both in selecting and fracturing the stones, that it is found to be the employment of particular, generally old men, who are laid aside from hunting, to make arrow- and spear-heads.' (Quoted by Stevens, 1870, p. 78.)

Stevens (1870, pp. 77–78) quotes Caleb Lyon on the manufacture by percussion of an obsidian arrow-head by a skilled workman of the Shasta tribe in California. This account is also quoted by Evans (1897, p. 40) with reference on p. 39 to sources. Details of the sources used by Stevens and Evans are collected in the Bibliography under Caleb Lyon's name. Holmes (1919, p. 299) quotes the account, with the reference 'Lyon, Letter of 1860'. His extract ends the description of the process as follows. 'I then requested him to carve me one from the remains of a broken port bottle, which (after two failures) he succeeded in doing. He gave as a reason for his ill success, he did not understand the grain of the glass. No sculptor ever handled a chisel with greater precision, or more carefully measured the weight and effect of every blow, than this ingenious Indian, for, even among them, arrow making is a distinct trade or profession, which many attempt, but in which few attain excellence. He understood the capacity of the material he wrought, and, before striking the first blow, by surveying the pebble, he could judge of its availability as well as the sculptor judges of the perfection of a block of Parian.'

Holmes (1919, p. 321) quotes Powers (1877, p. 104): 'Arrow-head manufacture is a speciality, just as arrow-making, medicine, and other arts.'

Sellers in his paper (1885, p. 874) recalls Catlin's account to him on the latter's return from his travels among the western Indian tribes. 'Most of the tribes had men who were expert at flaking, and who could decide at sight the best mode of working.' Pp. 874–5: 'The best flakes, outside of the home-made, were a subject of commerce, and came from certain localities where the chert of the best quality was quarried in sheets or blocks, as it occurs in almost continuous seams in the intercalated limestones of the Coal Measures. These seams are mostly cracked or broken into blocks, that show the nature of the cross fracture, which is taken advantage of by the operators, who seemed to have reduced the art of flaking to almost an absolute science, with division of labor, one set of men being expert in quarrying and selecting the stone, others in preparing the blocks for the flaker.' (Quoted also by Sir Daniel Wilson, 1889.)

Sellers (pp. 872–3). 'Major S. H. Long, afterwards Colonel, who in the latter part of his life succeeded Col. John J. Abert as head of the Topographical Department of the United States Army, whenever in Philadelphia, was a frequent visitor at my father's house, and when preparing for his expedition to the Rocky Mountains, in which my mother's youngest brother, Titian R. Peale, went as assistant naturalist, I saw him almost daily. The subject of flaking and forming arrow- and spear-heads was one of frequent discussion. . . . The expedition returned, and as far as I know, without any positive information as to the process of making the flakes. Mr. Peale said that he had seen squaws chipping flakes into small arrow-points, holding the flake in their left hand, grasped between a piece

of bent leather, and chipping off small flakes by pressure, using a small pointed bone in the right hand for that purpose. From this it was evident that John Smith's story was no myth. . . . He [Colonel Long] said that flakes prepared for points and other implements seemed to be an object of commerce among the Indian tribes that he came in contact with, that there were but few places where chert or quartzite was found of sufficient hardness and close and even grain to flake well, and at those places there were men very expert at flaking. He had understood that it was mostly done by pressure, and rarely by blows, but he had never witnessed the operation.'

Sir Daniel Wilson (1889, p. 84) describes a visit he made in the summer of 1854 to a group of Chippewa lodges on the south-west shore of Lake Superior. 'But they had also their stone-tipped arrows, and one Indian was an object of interest to a group of Indian boys as he busied himself in fashioning a water-worn pebble into an edged tool. He held an oval pebble between the finger and thumb, and used it with quick strokes as a hammer.'

The Stone-worker in Australia

Professor Porteous (1931), writing of the aborigines of the Kimberley area, says (p. 109): 'No one can contemplate the fine workmanship of these beautifully symmetrical spear-heads without feeling that the aboriginal craftsman has proceeded far beyond merely utilitarian ideas towards an appreciation of beauty of form and perfection of achievement.' On p. 112 he writes: 'Quite evidently some of the blacks are much more skilled in the art of stone-flaking to a preconceived design, and no doubt such artists are of much value to the tribe. Among the Kimberley natives the art is very generally practised, even youths and boys being observed very busily at work.' Plate XVII of the book shows stone spear-head manufacture.

Love (1936), also writing of the northern Kimberley area, and in particular of the Worora tribe, says (p. 74): 'While the women are away all day hunting, the main occupation of the men is making stone spear-heads. These stone spear-heads are the finest artefacts of the Worora. Of about the size and shape of a rose leaf, with finely serrated edges, they are made by percussion, then flaking by pressure, with stone, bone, and wood tools, from several kinds of fissile stone. The Worora man, in his hunting, always keeps his eyes open for useful bits of stone that will make spear-heads. He will take up a piece of broken rock, the size of his fist, lying on the surface of the ground, and test it by striking it with any convenient lump of stone lying about that will serve as a hammer. He will knock pieces off the edges of the stone he has noticed. If it flakes nicely he will break it down to somewhere near the size of a spear-head, and put it in his paper-bark wallet, to be dressed into shape at his leisure in his camp.'

Love (1936, p. 75). 'The whole work of making stone implements is a highly skilled art. Some of the stones used are semi-precious, as agates and crystals. The completed spear-head is a really beautiful object, with a needle point and wonderfully symmetrical edges. Boys and youths who have not been initiated as full members of the tribe are not allowed to try making these stone spear-heads,

of which the Worora are justly proud. Yet all this highly skilled labour is for one throw of the spear! The stone points are very brittle, and consequently break when thrown, unless the spear should pierce a soft part of the beast and be retrieved unbroken. More often than not, the point is broken off in the kangaroo that is struck, so that, even when the throw is successful and the hunter retrieves his spear after one throw, the stone head has to be renewed. No wonder the making of stone spear-heads is the main occupation of the Worora men. The wonder is that such care is lavished on an article destined to have such a short life. All the men make good spear-heads. I cannot name any man who cannot make a good one, though some are even neater than others. When the stone is finally shaped, serrated and complete, the artist (for artist is the proper name for him) puts the new spear-head in his mouth, wets it, and holds it up to appraise its beauty and keen point. If it is a translucent stone, he holds it up to the light and lovingly ponders over its colour. The men love to choose beautifully coloured stones for the making of the spear-heads. . . .'

Idriess (1949, p. 59) says of the aborigines of the north-west Kimberley area, north of the King Leopold Range, '. . . the aboriginal does not consider work or time if the subject he is engaged upon interests him'. On p. 172 he writes: 'Several of the primitives passed the time away by flaking stone spear-heads, fashioning them very much as glass ones are made nearer civilization. Only here they had no wire tools; they gouged the finer chips from the stone with spike-like tools of pointed kangaroo bone—*chumbee* they called these chipping-bones. It seems unbelievable that hard flint can be flaked or chipped by bone, but these primitives were managing it methodically. The only difference was that the work was harder and slower than on glass. One old expert, forgetting all about the patrol, gradually became absorbed in his job. He bit his lips, staring down at the fashioning spear-head, levering with his body stiffened, eyes and mind and cunning hand concentrated on every chipping. He cut his finger on a splinter, absentmindedly wiped the blood off on his hair, and bent again to the job. For the last chipping which makes the needle point and tiny serrated edges so true and delicate, he used a smaller bone, and with magic touch produced a truly exquisite thing. But he did not finish the job until sundown.'

For other remarks on aboriginal craftsmanship, the reader is asked to consult Professor Elkin's paper in *Man* (1948), already quoted on p. 89.

Chapter X

THE FLINT-WORKER'S MATERIAL

THE subject of Man's use of siliceous material for his tools and weapons is very great, and would need prolonged research and work in the field in order to deal with it at all satisfactorily, for each geographical area has its own formations of siliceous stone, and the men living in that area would have their own special problems of obtaining and treating the material. W. H. Holmes in his treatise on the Lithic Industries of North America (1919) most excellently performed this task as it concerns that area and the American Indian, and the student will find his work a mine of information on material, and on the technical methods used by primitive man to deal with it successfully.

Siliceous stone is only found in certain areas.[1] Furthermore, it may even in those areas be difficult to get good flaking-material. The first thing that the modern experimenter finds in England is that good flaking-flint is very rare. In England the chalk area is limited, and even in places where there is chalk it is very hard to get good material. Weathered flint is no good, and flint that has been washed out of the chalk is intractable.[2] Many flint seams are composed of nodules either impossible in shape or bad to flake. In fact, a seam of good flint is a treasure, and when it was found by the primitives it resulted in the long-timed and extensive working seen at Grimes Graves in this country, and at Flint Ridge in Ohio.

However, Man by virtue of his intelligence and adaptability could find sufficiently good substitutes for stone, and need not therefore be entirely dependent on it. Wood, shell, bone, ivory, and teeth are all effective in their various ways, and were used by Man for his tools and weapons, either with or without the addition of stone.

It would labour the point to attempt to give many examples, for these materials were all used, even where flint was available, at any time or place where men lived. Special mention, however, may be made of the Neolithic-type adzes made from solid shell, keen-edged and in colour and weight like ivory, used by the natives of the Caroline Islands, Aua

[1] This has been pointed out, as it applies to America, by Sir Daniel Wilson, 1889 (see p. 98), and by Major Long, as quoted by Sellers, on p. 93.

[2] In the writer's experience, weathered flint or redistributed flint may be possible to flake and shape, but the pieces crack easily, flaking is tough and uncertain, and the resulting implement looks very crude.

Island, and the Pelew Islands in the Pacific, of the weapons edged with shark's teeth used by the Kingsmill Islanders in the Pacific, of the knife of bamboo, the edge sharp and easily renewed by tearing off a thin strip, used by natives of New Guinea, and of the use of bone and ivory by the Eskimo. The use of bone and antler for arrow-points, and of teeth for knives and chisels by an inland Iroquoian Indian tribe is shown in W. J. Wintemberg's (1936) report on the Roebuck prehistoric village site, and the use of bone, antler, and teeth by a coastal Indian people, probably Micmac, is illustrated by Wintemberg and Smith (1929) in a report on shell-heaps in Nova Scotia. These reports and their illustrations will serve to emphasize the value to the primitive of these materials, and of their use to him. One would imagine that in working bone, antler, and ivory, even a chip of stone would be most essential for cutting and sawing them into form. It may be of interest to see what the authors of the Reports just mentioned have to say about the knives of these two Indian peoples.

Wintemberg (1936, p. 52) writes: 'Knives were almost indispensable in shaping or carving wooden, bone, antler, and shell artefacts, but no stone artefacts specially made for the purpose were found. It is probable, however, that some of the arrow-points may on occasion have been used, and also sharp chips of chert and quartz crystals, of which several pieces were found. The sharp edges of some of the chips would readily cut pieces of bone and antler, especially if the antler were first softened by boiling in water. It is probable that a chert chip blade was inserted in the narrow socket of the antler handle seen in Plate XIV, figure 10.'

Smith (1929, p. 69) writes as follows concerning implements used for cutting by Indians anciently living at Merigomish Harbour in Nova Scotia: 'Cutting was probably done with flakes of stone, and with knives and scrapers chipped from stone, beaten out of copper, and made of beaver and woodchuck teeth.'

Observations in these reports on prehistoric Nova Scotian tribes suggest that abundance of suitable material does not necessarily mean that it will be used. In the report on the Eisenhauer shell-heap, Wintemberg (1929, p. 114) writes: '*Animal Materials*. Evidence was found that bone, antler, and teeth were used as material for artefacts. Although there was an abundance of shells, not a single artefact was made of this material; in fact, shell artefacts are rare in shell-heaps along the northern Atlantic coast.' In his report on Merigomish Harbour in Nova Scotia, Smith (1929, p. 20) says: 'In fact, objects made of shell are rarer in the shell-heaps and elsewhere on the Atlantic and Pacific coasts of Canada than they are in the mounds of the interior of the continent.'

Flint

Most suitable of all material for the primitive is flint or flinty stone, for flakes from siliceous stone have the keenest of hard edges. These edges

can be easily serrated to turn them into saws, and the flakes themselves when chipped into implements may be formed with serrated cutting edges, and extremely sharp hard points; so also with the larger implements made from seam and nodular material. Some references from literature may be of interest for the light they throw on the way in which the worker regards his material, and on the shape and type of the siliceous formations he has to tackle before he can manufacture flint tools and weapons, for the shape of his raw materials will influence his technical methods.

Appreciation of Fine-quality Stone

Of the American Indian, Sir Daniel Wilson (1889, p. 83) writes: 'The old arrow-makers evidently derived pleasure from the selection of attractive materials for some of their choicest specimens of handiwork.' Of the Australian aborigine, J. R. B. Love (1936, p. 75) says: 'The men love to choose beautifully coloured stones for the making of the spear-heads.' Another point of view is given by W. H. Holmes (1919, p. 320, quoting Chever, 1870, pp. 139–40). 'Obsidian and agate are probably selected not so much for beauty of colouring as for their close grain, which admits of more careful shaping.'

The writer's experience with the fine materials of beautiful colour, such as jasper, chalcedony, obsidian, &c., has not been extensive on account of the difficulty of obtaining these materials for experimental purposes. But such experience as he has had does suggest that fine flaking-quality accompanies beauty and fineness of material. If this is indeed the case, then it would be all the more reason why beautiful material should be prized by the stone-worker.

Quarry Rights

As an American example, Holmes (1919, p. 318) quotes an extract from Father Morice (1895, p. 65) that illustrates native quarry rights. 'The material chosen in preference to fashion arrow or spear heads with was loose, broken pieces of the rock, such as were found on the surface. Of course, these were confined to a few localities only, wherein were situated sorts of quarries which were very jealously guarded against any person, even of the same tribe, whose right to share in their contents was not fully established. A violation of this traditional law was often considered a *casus belli* between the co-clansmen of the trespassers and those of the proprietors of the quarry.'

Giving an Australian example, Mitchell (1949, p. 96, quoting Howitt, 1904, pp. 311–12) writes: 'But there were places which such a group of people claimed for some special reason, and in which the whole tribe had an interest. Such a place was the "stone quarry" at Mt. William near Lancefield, from which the material for making tomahawks was procured. The family proprietorship of this

quarry had wide ramifications, including more than Wurunjerri people. On the one side it included the husband of Billi-billeri's sister, one of the Headmen of the Kurnung-William, who lived at Bacchus Marsh, and one who was named Nurrum-nurrum-biin, that is, "moss growing on decayed wood". On another side it included Ningu-labul, and in another direction Bebejern, the son of an heiress in quarry rights, from whom an interest came to Berak through his father Bebejern. But it was Billi-billeri, the head of the family whose country included the quarry, who lived on it, . . . his place was taken by the son of his sister, the wife of Nurrum-nurrum-biin, who came on such occasions to take charge, when it may be assumed, like Billi-billeri, he occupied himself in splitting stone to supply demands. The enormous amount of broken stone lying about on this mountain shows that generations of the predecessors of Billi-billeri must have laboured at this work. When neighbouring tribes wished for some stone they sent a messenger to Billi-billeri saying that they would send goods in exchange for it, such as skin-rugs. . . . If however, people came and took stone without leave, it caused trouble and perhaps a fight between Billi-billeri's people and them. Sometimes men came by stealth and stole stone.'

Search for suitable Stone and Trade in it by the American Indian

Sir Daniel Wilson (1889, p. 77) writes on the search for material by the Indian stone-workers, and their travelling long distances to obtain supplies of material best suited for the manufacture of different classes of implements. On pp. 84–85 he also writes: 'But suitable and specially prized material were sometimes sought on different sites, and disseminated from thence by the primitive trader. Along eastern Labrador and in Newfoundland arrow-heads are mostly fashioned out of a peculiar light-grey translucent quartzite. Dr. Bell informs me that near Chimo, south of Ungava Bay, is a spot resorted to by the Indians from time immemorial for this favourite material, and arrows made from it are not uncommon even in Nova Scotia. Among the tribes remote from the sea-coast, where no exposed rock furnished available material for the manufacture of their stone implements, the chief source of supply was the larger pebbles of the river beds. From these the most suitable stones were carefully selected, and often carried great distances.'

Siliceous Material in North America

Sir Daniel Wilson (1889) writes on p. 71: '. . . the chert, or hornstone, which abounds in the chert layers of the corniferous formation, [is] of common occurrence in Canada. . . . This Devonian formation is made up chiefly of limestone strata, parted in many places by layers of chert which vary in thickness from half an inch to three or four inches. The limestones are more or less bituminous, and frequently contain chert nodules. . . . The formation underlies a considerable portion of south-western Ontario.' On p. 85 he also writes: 'The finest flint implements of Canada are those of the north shore of Lake Huron, made from a material corresponding to a very fine grained quartzite, approximating to chalcedony, found among the Huronian rocks of that region. Dr. Bell has referred to this in his report for 1875.'

W. H. Holmes (1919, p. 188) writes of the chert concretions used in the manufacture of large chipped blades at Mill Creek Quarries, Illinois: 'The transverse section is very uniformly that of a flattened lens, which adapted them especially to the chipping operations of the aborigines.'

Thomas Wilson (1899, p. 874) says: 'Flint Ridge, Ohio [Plate 13, his paper] is a locality noted for its ledge deposit of flint, while the flint disks from Ohio and Illinois [Plates 62, 63, his paper] show deposits to have been in nodules.' Later on the same page, Wilson gives excerpts from Hall's 'Pentamerous limestones of the Clinton group' (1843) indicating the existence of flint in strata and in nodules in parts of New York State.

Another extract from Thomas Wilson's paper (1899, p. 908) is interesting in its reference to the use of thin seam material by the American Indian worker. 'Fig. 126 [his paper] is another of the long, narrow, and thin flint or jasper implements from the Pacific Coast. Although it is 7¾ inches long and 2 inches wide, it is but one-eighth of an inch thick. It, with two or three other specimens, is peculiar in that though thin, they have not been reduced by chipping. They are quite flat in section, reduced in thickness only to form the edge. This peculiarity is caused by the layer of flint being a natural formation in its present thickness. The deposit of flint, however made, has been intercalated with a layer on each side of what has the appearance of lime or chalk, the surface being broken by right lines into parallelogramic figures, as shown in the illustration. Only slight chipping was necessary to reduce the implement to a sharp edge. For the better understanding of this, reference is made to Plate 31, fig. 2 [Wilson's plate].'

Professor E. B. Tylor describes the use of obsidian and chalcedony by the Indians of Mexico in *Anahuac* (1861, p. 99). 'About here, some of the trachytic porphyry which forms the substance of the hills, had happened to have cooled, under suitable conditions, from the molten state into a sort of slag or volcanic glass, which is the obsidian in question, and in places, this vitreous lava—from one layer having flowed over another which was already cool—was regularly stratified.' This was at Cerro de Navajas, the 'hill of knives', which is shown on the map in the book. On p. 96, Tylor shows a spear-head of chalcedony, and says 'this peculiar opalescent chalcedony occurs as concretions, sometimes of large size, in the trachytic lavas of Mexico'.

Siliceous Material in Australia

Spencer and Gillen (1904, p. 365), writing of Central Australia, say: 'In regard to [the aboriginal stone implements], as a whole the most interesting feature is that one and the same tribe will not only use but make roughly or most carefully flaked stones, chipped stones, and ground axes. . . . Amongst the Central Australian aborigines, it is simply a question of the material available. If they have a supply of quartzite, then they make flaked or flaked and chipped implements.' P. 640: 'Flaked knives [are made] of quartzite, a quartzite that varies in structure from a close-grained quartzite to that of a smooth opalescent

quartzite. In some form or another quartzite is distributed over a very large area of Central Australia.'

Spencer (1914, p. 353): 'The one thing that stands out clearly, is that the nature of the stone weapon, or implement, used by an Australian aboriginal is determined, primarily, by the nature of the material available. If he lives where he can secure only quartzite, or some such rock, then he makes chipped and flaked implements. . . . If he lives where he can secure diorite and rocks of that nature, then he grinds his stone implements and, if he lives where he can obtain both quartzite and diorite, then he makes flaked, chipped, and ground implements, just according to what material lies handiest.'

McCarthy (1943, p. 129), concerning the ancient implements found on the south coast of New South Wales, writes: 'A wide range of siliceous materials (Harper, 1915) is represented, including chert, chalcedony, quartz, flint, jasper, latite, slate, quartzite, and porphyry, and silicified wood, tuffs, shales, grits, and tertiary sands. . . . No doubt some local outcrops of stone were favoured for making artefacts, and stone from them traded between groups of natives, because a considerable proportion of the materials has been brought to most of the kitchen middens along the south coast.'

Of the northern Kimberley area, Professor Elkin (1948, p. 110) writes: 'In the Kimberleys the kind of stone used is a quartzite, varying in colour from white to red, though Mr. Best says that the Drysdale River natives prefer a "hard slatey grey stone". This is broken up with any available piece of hard hammer stone into crude cores of anything up to two or even three pounds in weight. These are carefully examined, the pieces deemed satisfactory being kept for further working. In the Victoria River region of the Northern Territory, flint is said to be used.'

Mitchell (1949, p. 18) writes: 'The aboriginal's choice of a stone material was guided by a knowledge of its physical properties gained in the hard school of experience; it had been handed down to him by his forbears but he himself was seemingly always an experimentalist. For many purposes his preference seems to have been fine-grained quartzite, but when that was not forthcoming he used quartz, flint, jasper, or some other rock. For a specific purpose a particular kind of rock may have been desirable, such as diabase, so widely used in Victoria for edge-ground axes.'

Mitchell's book contains much valuable information on the material used for implements by the Australian aborigines.

Chapter XI

CHANGE IN TECHNIQUE, AND THE UNDERLYING IDEA IN TECHNICAL METHODS

In a representative museum collection of flint implements from early to late periods, time and development are foreshortened, and changes which took many hundreds and thousands of years to develop appear to have arisen in the space of one exhibition case to another. Yet many must have been the slight changes in the accepted techniques of the time, some perhaps due to accident owing to the material used and its shape in its raw state, some to the individual variations inherent in a handicraft, and some due to the experimental genius of the individual worker seeking to better the standard methods, before the underlying idea in the stone-working methods of the period became changed, a new idea considered an improvement on the old one accepted, and a new technique born. Inventive genius must have been stimulated and new ideas called forth by new wants brought into being by changes in living conditions due to climate, new environment, or survival in the face of the hostility or competition of other peoples. All these causes might well evoke new or improved ways of dealing with wood, antler, and other materials in general use, necessitating new forms of stone tools, or urge the need for new and improved forms of stone implements to arm new or improved weapons.

The foregoing observations will apply only to the main stream of development of technical knowledge, for there are many cross-currents, eddies, and backwaters. Nevertheless, taking Mankind as a whole, it seems reasonable to suppose that technical equipment developed little by little in the manner indicated above. Otherwise the civilized and metal-using peoples of later times would never have emerged from the Stone Age peoples of the world, and there would never have been any technical advance anywhere. The backwaters and cross-currents may be illustrated by two peoples of modern times, the Tasmanians and the Bushmen of South Africa.

The Tasmanian Aborigines

These people were armed only with wooden spear and club. In their stone tools they might be classed as 'Upper Palaeolithic', for they made

and used many of the types characteristic of that period in Europe and elsewhere. Some of their stone tools were crude picks, choppers, and flakes reminiscent of Lower Palaeolithic types and flaking methods; on the other hand some of their flaking was quite fine, and many of their flaked cores were of Later Stone Age type. Technically they were much behind their nearest neighbours the Australian aborigines. They had not developed the grinding and polishing of stone to make adzes and axes, nor did they make flaked-points. Yet they lived and held their own in their environment; the sea saved them for a long period from the encroachment of more progressive peoples; their tools were sufficient to supply their wants, and their weapons were sufficient for their intertribal quarrels. So far as we can tell, they lived as contentedly and healthily as other native peoples. It was only when they were confronted by the invading European with his firearm that their want of 'progress' proved fatal to their existence.

The South African Bushman

Here we are dealing with a Stone Age people whose strength lay in its ability to live in a harsh and arid environment, and in its employment of poison on weapons so as to hold its own against hostile iron-using neighbours. There was no need of an elaborate arrow-head; a chip-edged arrow-point covered with poison was deadly though the wound inflicted might be slight. The Bushmen built no houses and used no boats, and there was therefore no need for the ground-stone adzes of other peoples. Yet archaeologically there seems to be evidence that their ancestors had made and used adzes[1] and finely flaked arrow-heads and spear-heads, and were culturally nearing the Neolithic stage (Lowe, 1947, p. 91). If that is so, then the change to a more arid environment owing to the pressure of hostile tribes, and the development of poison as a weapon, may have caused a retrograde condition so far as stone-work was concerned, although the stone tools they did use were well made and included characteristic Upper Palaeolithic and Mesolithic types. A people on the verge of a considerable cultural advance may have been driven back so far as material and technical advance was concerned. Nevertheless, intelligence, adaptability, and technical methods concentrated on the preparation and use of poison enabled the Bushman to hold his own, until eventually confronted by the firearm that far outranged his poisoned arrow.

[1] Often called 'axes', but casts of three in the Pitt Rivers Museum appear to be adzes.

The Part played by the Individual in Technical Advance

It is an interesting question as to how far technical advance can occur in primitive society by the effort of the individual worker. In periods of general advance, inventions by the worker would be welcomed and incorporated forthwith if they proved to be useful. This can be seen in the history of our own times, and equally from history may be seen objections and obstructions to revolutionary changes in technique.

That advance in the realms of thought could be severely dealt with if it ran counter to the ruling opinion is shown in the history of mediaeval and earlier times, and even now in our own day. The primitive appears to have been deeply conservative and traditionally minded, and there may have been good reasons for this in his adaptation to his environment. It was when the Europeans came that there was need for revolutionary changes in his material and cultural life if he were to survive the impact, and for some of the backward peoples the change was too much.

Advance within a limited area is shown by the stratified deposits of the French caves, and by those of the caves on Mt. Carmel in Palestine, excavated by Professor D. A. E. Garrod. Here in chronological sequence can be seen the gradual development of new forms of technique and new forms of tool. These developments may be due to individual effort, to individualism plus outside contact, or to outside contact (culture-contact) alone. But if due to the last two, the question still remains as to how the 'outside contact' developed its superior technique. Perhaps there were periods of acute activity stimulated by changes in environment or conditions of life. Always there is the desire for change and novelty in each succeeding generation of youth. These may be some of the springs at the source of progress.

An Example of Technical Advance

Perhaps of all stone techniques the core technique, whereby the worker obtained his essential flake-tools, best shows the change of thought and practice that, from a general and universal point of view, added to the techniques of the stone-worker.

The earliest core technique represented in the Pitt Rivers collections is that of the Clacton and Clacton-type. In this technique the worker used flattened nodules or pieces and struck off flakes from the edges in the obvious and easiest way. This is probably the earliest core technique, yet one that was always found useful at times and places in stone-working, even in the latest Stone Age times.

Gradually the worker found that it was possible to form the shape of the flake he wanted on one face of the mass of stone he was using as a core, instead of going on striking rather clumsy flakes from the edges of the piece. At the back of his quest for a particular flake there must have been a number of compelling factors and the urge for a symmetrical flake of some needed form. Eventually he found that by improving on this technique by using different forms of core, he could obtain a number of different forms and sizes of flake-implements. Thus in the full development of the 'tortoise'-type core a very efficient form of flake and flake-implement technique was established, was widespread, and was characteristic of what may be called the Middle Palaeolithic period.

Then the urge arose for symmetrical flakes, narrow in proportion to their width, in different sizes, and capable of being produced in large quantities, and the Brandon-type and double-platform cores were the answer, for the requisite single-ridged and double-ridged flakes could be produced in large numbers from a suitably shaped core of either of these kinds, with the minimum of waste material, or a core of this kind could be kept, from which a fresh knife could be struck whenever the one in use became blunted, until nothing was left but a waste core to be discarded, while a fresh one took its place.

Now some forms of 'tortoise'-core were at their opening stages Brandon-type cores in being, and the double-platform core is plainly developed from a form of double-platform 'tortoise'-type core, so that the underlying idea in the stone-worker's mind had only to work in its development from one form of core to another. Yet the change was complete and final, and the 'tortoise'-type core is not to be found in the later prehistoric Stone Age, nor in the modern Stone Age industries of our own time (see pp. 46–52 for a detailed account of core types and their periods).

The changes themselves must have led to the search for material of suitable shape and quality, and so on to the later development of mining for siliceous stone. Improvements of one kind led to improvements in another, and to an ever-widening and increasing flow of needs accompanied by the means to satisfy them.

In the implement itself, the Lower Palaeolithic hand-axe shows the idea working in the variation from the essential and characteristic pear-shaped chopping and piercing instrument, a general purpose tool, to the chopper, cleaver, and dagger-shaped forms of the Late Acheulean period, and so on to the chopping implements, and possibly indirectly to the axes and adzes, of modern Stone Age peoples.

The flake develops into a number of implements for specialized purposes, and in time, when the bow is invented, may become the symmetrically flaked stone arrow-head of the Neolithic and later period.

The flaked spear-point and knife develop into the beautiful Egyptian Predynastic chert ripple-flaked knife, the Danish handled and fluted-flaked flint dagger, and the magnificent American Indian flaked knives, all three types the artistic and technical masterpieces of Man's work in flaking stone.

Chapter XII

FLINT-WORK AND THE FLINT-WORKER

FLINT, and other stone, make the most durable of Stone Age Man's tools and implements. The flakes struck off in the making of a flint implement show by the direction of the flake-scars the intention and skill of the man who shaped the piece of flint. The way in which the flake-scars were made, the technique, shows the degree of the worker's skill, intelligence, and knowledge of his material, while the form and variety of the implements themselves, among peoples who make considerable use of flinty material, may show the complexity of the worker's life, the cultural level to which he has attained, and his artistic feeling for beauty of shape and surface pattern.

It is therefore for the light they throw on the development of Man that so much interest lies in the study of stone implements, for their increasing fineness and complexity through the time periods shows the developing fineness and complexity of the mind of their users; the advance in technical methods shows the gradually acquired mastery of the material by means of experiment and inventive genius, and artistry and craftsmanship are shown in the shaping by skill of hand a difficult, often beautiful material.

It is necessary to stress at this point the early date at which fine craftsmanship was shown by Stone Age Man, for even as far back as the Lower Palaeolithic, the large finely made Acheulean-type hand-axes are, in their shape, symmetrical section, and the pattern of their cross-flaking, superb examples of skill in flint-flaking. Later, in the French Solutrean period of the Upper Palaeolithic, yet still remote in point of time, the large leaf-shaped flaked-points are, in their width, thinness of section, and the symmetrical cross-flaking of their surfaces, among the finest products of the flint-flaker at any date. Their size and thinness must have necessitated careful handling, and it may be that some mining experience was needed to find seams that would supply nodules of a shape that would lend itself to the manufacture of these wonderful examples of flint-work.

Surveying stone-working as a whole, the significant advance in the later periods was the invention of techniques that enabled the worker to use unflakeable stone. Nevertheless, flint was always in use where it was

plentiful and of good quality, and in those areas the later stone-worker with his advanced technical knowledge and specialized skill was able to manufacture flaked-implements of a perfection of shape and flaking-pattern that could not have been achieved by his distant ancestors.

The flaked-flint implement is an object of interest because of its material, symmetry of form, and flaking-pattern, and because of the technique of its manufacture. It has also the romantic association of places and times far off and long ago. But it is, above all, the very lasting evidence of the skill, inventiveness, and artistry of the Stone Age Craftsman.

BOOKS AND PAPERS MENTIONED IN THE TEXT

ARMSTRONG, A. LESLIE. 'Rhodesian Archaeological Expedition (1929): Excavations in Bambata Cave and Researches on Prehistoric Sites in Southern Rhodesia', *Journal of the Royal Anthropological Institute*, lxi, London, Jan.–June 1931.

BARNES, A. S. 'The Technique of Blade Production in Mesolithic and Neolithic Times', *Proceedings of the Prehistoric Society*, London, 1947.

BARNES, ALFRED S., and KIDDER, H. H. 'Différentes techniques de débitage à La Ferrassie', *Bulletin de la Société Préhistorique Française*, No. 4, Paris, 1936.

BASEDOW, HERBERT. *The Australian Aboriginal*, Adelaide, 1925.

BECKWITH, E. G. 'Report of Explorations for a Route for the Pacific Railroad on the Line of the Forty-first Parallel', *Reports of Exploration and Survey for a Railroad from the Mississippi River to the Pacific Ocean*, pp. 1–66, Washington, 1855.

BELCHER, CAPTAIN SIR EDWARD, R.N. 'On the Manufacture of Works of Art by the Esquimaux', *Transactions of the Ethnological Society of London*, N.S., vol. i, pp. 129–46, London, 1861.

BELCHER Collection, report from *Morning Post* on Exhibition by the Ethnological Society of London in *Révue Archéologique*, N.S., 2e année, vol. iii, pp. 341–2, *Paris*, 1861.

BIRD, JUNIUS. 'The Antiquity and Migrations of the Early Inhabitants of Patagonia', *Geographical Review*, vol. xxviii, pp. 250–75, New York, 1938.

BLACKWOOD, BEATRICE. 'The Technology of a Modern Stone Age People in New Guinea', *Occasional Papers on Technology*, 3, Pitt Rivers Museum, University of Oxford, 1950.

BORDES, FRANÇOIS. 'Étude comparative des différentes techniques de taille du silex et des roches dures', *L'Anthropologie*, tome 51, Nos. 1–2, Paris, 1947.

BUCK, P. H. *Samoan Material Culture*, Bernice Pauahi Bishop Museum, Bulletin 75, 1930.

CAMPBELL, T. D., and NOONE, H. V. V. 'South Australian Microlithic Stone Implements', *Records of the South Australian Museum*, vol. vii, No. 3, Adelaide, 30 May 1943.

CATLIN, GEORGE. *Last Rambles amongst the Indians of the Rocky Mountains and Andes*, London, 1868.

—— *Life among the Indians*, Edinburgh, 1874.

CHAMBERS, C. H.: see CASTALDI, B.

CHANDLER, R. H. 'On the Clactonian Industry at Swanscombe', *Proceedings of the Prehistoric Society of East Anglia*, vol. vi, parts I and II, London, 1928–9.

CHEVER, EDWARD E. 'The Indians of California', *American Naturalist*, vol. iv, No. 3, pp. 129–48, Salem, 1870.

COOPER, H. M. 'Large Stone Implements from South Australia', *Records of the South Australian Museum*, vol. vii, No. 4, Adelaide, 30 Nov. 1943.

DULOG, H. G. in *Forest and Stream*, quoted without date by Mason, O. T., 1894.

DUNN, E. J. *The Bushman*, London, 1931.

ELKIN, A. P. *The Australian Aborigines*, Sydney, 1938.

—— Review of Knowles, F. H. S., 1944, *Oceania*, vol. xv, 1944–5, p. 168.

—— 'Pressure Flaking in the Northern Kimberley, Australia', *Man*, 1948, No. 130, London, 1948.

EVANS, JOAN. *Time and Chance, the Story of Arthur Evans and his Forebears*, London, 1943.

EVANS, SIR JOHN. *Ancient Stone Implements of Great Britain*, 2nd ed., London, 1897.

FOX, COLONEL A. LANE. 'Excavations in Cissbury Camp, Sussex', *Journal of the Anthropological Institute*, vol. v, No. III, London, Jan. 1876.

GARROD, D. A. E., and BATE, D. M. A. *The Stone Age of Mount Carmel*, vol. i, Oxford, 1937.

GASTALDI, BARTOLOMEO. *Lake Habitations and Prehistoric Remains in the Turbaries and Marl Beds of Northern and Central Italy*, translated by C. Harcourt Chambers, London, 1865.

HALL, JAMES. 'The Pentamerous Limestones of the Clinton Group', *Geology of the Fourth District of New York*, part IV, 1843.

HARPER, L. F. 'Geology and Mineral Resources of the Southern Coal-Field', *Memoirs of the Geological Survey of New South Wales, Geology*, No. 7, Sydney, 1915.

HAWKES, C. F. C. 'Prehistoric Time', *Museums Journal*, London, Sept. 1941.

HOLMES, W. H. 'The Lithic Industries', *Handbook of Aboriginal American Antiquities*, Part I, *Bureau of American Ethnology*, Bulletin 60, Washington, 1919.

HOWITT, W. A. *The Native Tribes of South-east Australia*, London, 1904.

IDRIESS, ION L. *Over the Range*, Sydney, 1945. (Sketches of Aboriginal life written in the form of a novel.)

JOCHELSON, WALDEMAR. *Archaeological Investigations in the Aleutian Islands*, Carnegie Institution of Washington, Publication No. 367, Oct. 1925.

JOYCE, T. A. 'The "Eccentric" Flints of Central America', *Journal of the Royal Anthropological Institute*, vol. lxii, London, 1932.

KNOWLES, F. G. W. *Man and other Living Things*, London, 1945.

KNOWLES, SIR FRANCIS H. S., BART. 'The Manufacture of a Flint Arrow-head by Quartzite Hammer-stone', *Occasional Papers on Technology*, I, Pitt Rivers Museum, University of Oxford, 1944.

KNOWLES, W. J. 'Stone Age Factories near Cushendall, County Antrim', *Journal of the Anthropological Institute*, vol. xxxiii, London, July–Dec. 1903.

LACAILLE, A. D. 'Aspects of Intentional Fracture', *Transactions of the Glasgow Archaeological Society*, vol. ix, part IV. Read 16 Dec. 1939.

LARTET, ÉDOUARD, and CHRISTY, HENRY. *Reliquiae Aquitanicae*, London, 1875.

LEAKEY, L. S. B. *Adam's Ancestors*, London, 1934.

LOVE, J. R. B. *Stone Age Bushmen of To-day*, London, 1936.

LOWE, C. VAN RIET. 'More Neolithic Elements from South Africa', *South African Archaeological Bulletin*, vol. ii, No. 8, Cape Town, 1947.

LYON, CALEB (Extract from letter of). *Bulletin of the American Ethnological Society*, vol. i, p. 39, New York 1861. Also quoted in *Transactions of the Ethnological Society*, N.S., vol. iii, p. 365, London, 1864; and in *Reliquiae Aquitanicae*, p. 17, London, 1875.

MCCARTHY, FREDERICK D. 'An Analysis of the knapped Implements from eight *Elouera* Industry Stations on the South Coast of New South Wales', *Records of the Australian Museum*, vol. xxi, No. 3, Sydney, 28 June 1943.

MASON, OTIS TUFTON. 'The Ray Collection from Hupa Reservation', *Smithsonian Report for 1886*, part I, pp. 205–39, Washington, 1889.

—— 'North American Bows, Arrows, and Quivers', *Smithsonian Report for 1893*, pp. 631–79, Washington, 1894.

MITCHELL, S. R. *Stone-age Craftsmen, Stone Tools and Camping Places of the Australian Aborigines*, Melbourne, 1949.

MOOREHEAD, WARREN K. *The Stone Age in North America*, 2 vols., London, 1911.

MORICE, A. G. 'Notes on the Western Dénés', *Transactions of the Canadian Institute*, vol. iv, pp. 1–122, Toronto, 1895.

MORTILLET, G. DE. *Matériaux pour l'histoire de l'homme*, vol. ii, Paris, 1866.

MURDOCH, JOHN. 'Ethnological Results of the Point Barrow Expedition', *9th Annual Report, Bureau of American Ethnology*, pp. 19–441, Washington, 1892.

NELSON, EDWARD WILLIAM. 'The Eskimo about Bering Strait', *18th Annual Report, Bureau of American Ethnology*, Part I, Washington, 1899.

PATERSON, T. T. 'Core, Culture and Complex in the Old Stone Age', *Proceedings of the Prehistoric Society*, N.S., vol. xi, London, 1945.

PENNIMAN, T. K. *A Hundred Years of Anthropology*, London, 1952.

PORTEOUS, STANLEY D. *The Psychology of a Primitive People*, London, 1931.

POWELL, J. W. 'Stone Art in America', *American Anthropologist*, vol. viii, No. 1, pp. 1–7, Washington, 1895.

POWERS, STEPHEN. *Tribes of California, Contributions to North American Ethnology*, vol. iii, Washington, 1877.

PULL, J. H. *The Flint Mines of Blackpatch*, London, 1932.

REDDING, B. B. 'How our Ancestors in the Stone Age made their Implements', *American Naturalist*, vol. xiii, No. 11, pp. 667–74, Philadelphia, 1879.

Information about the use of a punch also in the *American Naturalist*, Nov. 1880, and in *Nature*, vol. xxi, p. 613.

Reliquiae Aquitanicae: see LARTET and CHRISTY.

ROTH, W. E. *North Queensland Ethnography*, Bulletin no. 7, 1904.

SCHOOLCRAFT, HENRY R. *Information respecting the History, Condition and Prospects of the Indian Tribes of the United States, collected and prepared under the Direction of the Bureau of Indian Affairs*, Philadelphia, 1851–4; another edition, 5 vols., Philadelphia, 1853–6.

SCHUMACHER, PAUL. 'Die Erzeugung der Steinwaffen', *Archiv für Anthropologie*, vol. vii, pp. 263–5, Braunschweig, 1874.

—— 'Methods of making Stone Weapons', *Bulletin of the United States Geological and Geographical Survey of the Territories*, vol. iii, pp. 547–9, Washington, 1877.

SELIGMAN, C. G., and STRONG, W. MARSH. 'Anthropological Investigations in British New Guinea: Axe-making site near Suloga in Woodlark Island (Murua)', *Geographical Journal*, vol. xxvii, London, Jan.–June 1906.

SELLERS, GEORGE ERCOL. 'Observations on Stone Chipping', *Annual Report of the Board of Regents of the Smithsonian Institution*, Part I, Washington, July 1885.

SHETRONE, HENRY CLYDE. *The Mound Builders*, New York, 1930.

SMITH, H. I. 'The Archaeology of Merigomish Harbour, Nova Scotia', pp. 1–104 in Smith, H. I., and Wintemberg, W. J., 'Some Shell-heaps in Nova Scotia', *Bulletin 47, Anthropological Series no. 9, National Museum of Canada*, Ottawa, 1929.

—— and WINTEMBERG, W. J. 'Some Shell-heaps in Nova Scotia', *Bulletin 47, Anthropological Series no. 9, National Museum of Canada*, Ottawa, 1929.

SMITH, CAPTAIN JOHN. *The General History of Virginia, New England, and the Summer Isles* (London, 1624, folio), vol. xiii, 1812, in Pinkerton, John, *A General Collection of the best and most interesting Voyages and Travels in all parts of the World*, 17 vols., London, 1808–14.

—— *The true Travels, Adventures and Observations of Captaine John Smith*, 2 vols., London, 1629.

SPENCER, BALDWIN. *Native Tribes of the Northern Territory of Australia*, London, 1914.

—— and GILLEN, F. J. *The Northern Tribes of Central Australia*, London, 1904.

STEVENS, EDWARD T. *Flint Chips, a Guide to Prehistoric Archaeology as illustrated in the Blackmore Museum, Salisbury*, London, 1870.

TYLOR, EDWARD B. *Anahuac*, London, 1861.

WARREN, S. HAZZLEDINE. 'Stone Axe Factory at Craig-Lwyd, Penmaenmawr', *Journal of the Royal Anthropological Institute*, vol. xlix, London, 1919.

WARREN, S. HAZZLEDINE. 'The Mesvinian Industry of Clacton-on-Sea, Essex', *Proceedings of the Prehistoric Society of East Anglia*, vol. iii, part IV, London, 1921–2.

WILSON, SIR DANIEL. 'Trade and Commerce of the Stone Age', *Transactions of the Royal Society of Canada*, vol. vii, section 2, No. 3, Ottawa, 1889.

WILSON, THOMAS. 'Arrow-points, Spear-heads, and Knives of Prehistoric Times', *Report of the U.S. National Museum, Smithsonian Institution*, part I, Washington, 1899.

WINTEMBERG, W. J. 'The Eisenhauer Shell-heap, Mahone Bay, Nova Scotia', pp. 107–92 in Smith, H. I., and Wintemberg, W. J., 'Some Shell-heaps in Nova Scotia', *Bulletin 47, Anthropological Series no. 9, National Museum of Canada*, Ottawa, 1929.

—— 'Roebuck Prehistoric Village Site, Grenville County, Ontario', *Bulletin 83, Anthropological Series no. 19, National Museum of Canada*, Ottawa, 1936.

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